The effects of changing resource use in the Marlborough Sounds

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The wake of a fast ferry, Marlborough Sounds.

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Abstract

The Marlborough Sounds is an area of New Zealand that possesses great scenic beauty. The area is biculturally and ecologically significant, a recreational haven and is a great resource both economically, historically and environmentally. The physical appearance of Marlborough has radically changed over the last two centuries due to human occupation and development of water resources (such as trasportation, recreation, and mussel and fish farming) and land land resources (such as forestry, conservation and residential development). Development in the Sounds has been occurring due to increased demand for resources both on land and in water, forming a collage of different land and water uses. Some activities in the Marlborough Sounds are having a detrimental effect on the environment due to unsustainable development. This thesis examines some contemporary issues relating to the environmental effects that land and water uses are having on the Marlborough Sounds Area. The topic is examined through two main themes, forestry and fast ferries and their effect on the coastal zone.

Productive land uses in the Sounds are limited due to the steep sloped topography and low fertility soils. Exotic forestry plantation is one of the few land uses that can excel in such conditions. Development in the area has moved from farming to forestry as wool and meat prices declined and as soil fertility decreased with burning as a form of weed control. However, there have been problems in the conversion to forestry. Wilding pines are penetrating the regenerated native forest that does remain. This forest type is unique as it is the southern-most point for many native species. Another effect of forestry in the sounds is its influence on the coastal zone through sedimentation. Mass siltation causes bay infilling or suspended sediment levels to increase. This occurs at greatest rates when clearing the land to plant or when logging. This has effects on other land and water uses, such as marine farming and recreation (as the aesthetics of the hillside during logging are decreased).

Development of the Marlborough Sounds has also occurred on water. From the time Tory Channel was discovered, it has been heavily utilised. First by Maori canoes, then early whalers, cargo ships, cruiseliners and since 1962 ferry traffic between Wellington and Picton. The vital transport networks and infrastructure have aided in the development of the region. This has led to an increase in large boat traffic in the Marlborough Sounds resulting in different wave energies working the shoreline. The second theme of this thesis discusses the recent introduction of the 'fast ferries' and how they have caused the remodelling of beach morphologies in the ferry corridor. The change to various beaches and rock outcrops in the Sounds has been significant but it is difficult to interpret the cause of change as a number of factors influence the shoreline. People's perception of fast ferry damage is often different to fact. A variety of situations where alleged damage to the coastline and coastal structures are examined.

Key words: Marlborough Sounds, forestry, fast-ferries, coastal zone, landscape, resource.

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CHAPTER ONE

Introduction

View of Queen Charlotte Sound looking north past Allports Island towards the northern passage.

'At first there was nature. It included the earth and the sky and the stars in the sky and all that was and lived on the earth – rocks and sand, fauna and flora, earth and water, energy and matter. Then came man, who alone of all living creatures was given the power to lift himself out of the compass of nature and the ability to set his will against the will of nature and to shape nature, or parts of it, to his will and thereby to strengthen his hand in his struggle with nature. Thus there arose that lofty edifice that we call culture' (Zimmermann, Peach and Constantin, 1972).

1.1 Thesis Issue

This thesis examines the changing landscape of the Marlborough Sounds and the effect of this change on the coastal zone. The focus is on resource use of land and water in the Sounds especially on water use by fast ferries and the land use of forestry. These two uses have been controversial due to their effects on the environment and the people using it. Uses of land and water have developed as humans have developed, and human culture has aided in the change of the landscape in order not only to live but also to flourish (Zimmermann *et al.* 1972). The uses of the Sounds area are important for local people's livelihood and the economy of both the Sounds and of New Zealand and hence resources have been realised and utilised due to their financial return. There are multiple resources in the Sounds, some of them have not yet been fully realised and developed to their potential. The planners of the area must have the foresight to see what people will value in the future, conserving the area or developing it. Can both conservation and development occur in harmony through sustainable management using the Resource Management Act (1991)? This thesis aims to discuss how management of the Sounds has formed the current situation and how, the Sounds could be effectively managed to encompass everyone's needs, today and in the future.

It is often useful to begin with some definitions. Two key words in this thesis are development and landscape. A working definition of 'development' that is proposed by The Nature Conservation Council (1981, P.9) is 'The modification of the biosphere (the thin covering of the planet that contains and sustains life) and the application of human, financial, living and non-living resources to satisfy human needs and improve the quality of human life'. 'Landscape' is defined by Whitton (1984, P.301) as 'the total surface form of any area, rural or urban, and includes both natural and man-made features'. These definitions will be used when referring to landscape or development throughout the text.

1.2 Landscape change and the Marlborough Sounds

The Marlborough Sounds are part of the wider Marlborough Region. The physical appearance of the Marlborough region has changed radically over the last century. Before European occupancy most of the land was covered in native bush. Most of the land has since been cleared for farming, agriculture and viticulture and land that cannot be utilised in this way has been developed for forestry. Along with this change a wide realm of transport networks have evolved. A new domestic airport has recently been built with flights to more destinations and more ferries have been introduced to move passengers and freight between the two islands. Shakespeare Bay has recently been built into a major Port for the export of timber and potentially, coal. These vital transport networks and infrastructure have aided in the development of the region.

The Sounds have also participated in this drive for change in the Region. Pioneering New Zealanders have utilised a wide range of techniques in order to control the land. The different uses of the Sounds have led to the landscape becoming disjointed in its appearance. Over the last 150 years the area has undergone a large amount of change. Change has occurred as resources have been realised and technology has enabled utilisation both actually and economically. Both land and water activities have changed how the Sounds are perceived, as people do not segregate the land and the water outlook when they view the Sounds because the land and water become a continuum of the scene. This accentuates the need for holistic management.

Land and water development has influenced the coastal zone due to various management practises. The coast is arguably the most heavily used space in the Marlborough Sounds and is valued highly for a number of resources it encompasses. This area is biculturally significant for its rich resources, history, ecology and its aesthetic value. However, it is also increasingly significant economically and recreationally. Both economic and recreational activities are transforming the landscape at a rapid rate. The Resource Management Act was introduced in 1991 to instigate sustainable management and to avoid, remedy or mitigate adverse effects on the environment. Therefore it is important to clarify effects to land and water uses in the Marlborough Sounds and the causes of those effects, especially those that are human in origin.

This thesis explores contemporary issues relating to two resource uses and tension between them in the Marlborough Sounds. The Sounds has many unique landscape qualities that are important to consider when utilising the area, as they could be lost if continuing development of the area proceeds.

Within the broader picture of transformation of the Marlborough Sounds are the transport links that aid development. The first theme to be discussed in this thesis is the changing water environment of the Sounds. There has been a large increase in ship traffic in the last decade of the last century. Its significance is important to the study as boat wake waves are introducing a different wave regime to the coast – changing the use and perceived value of some areas. The increase in large boat traffic in the Marlborough Sounds and its effect on the coastline is an area to be discussed in this thesis. It is a complicated and contentious issue as many residents in the Sounds are attracted to the quiet isolation and find that the increase in boat traffic is affecting their use of what has been called the 'Ferry Corridor'. In conflict with this, the ferries are providing a service for the community, on a national scale for New Zealand, and at a regional scale for the province of Marlborough.

Wave action and tidal currents work to form and mould the shoreline. For over 200 years, Tory Channel and Queen Charlotte Sound has been a major shipping route, starting with early explorers, through whaling years to the present day commercial ferry service, cruise liners and cargo carriers, hence changing the wave regime of this area of the Sounds from its natural state. However it is important not to look at ferry waves and natural waves in isolation because all waves are influencing the shore. The recent introduction of the fast ferry service in December 1994 has led to the addition of new elements in the wave action working the shoreline of the ferry corridor. As a result there has been a perceived change to various beaches and rock outcrops in the Sounds. A section of the thesis aims to explore shoreline change since the introduction of the fast ferry service.

The fast ferry issue will be approached in this thesis by explaining the context of the problem in a broad sense followed by an examination of the ways in which the ferries are affecting the area economically, culturally, as hazards to people and environmentally with special emphasis on the coastal environment. This chapter will discuss how people's perception of change and actual change can differ. The management of the ferries will also be addressed.

The second theme to be addressed in this thesis deals with change to the coastal zone that has occurred due to landscape change. Major clearance of the land began during

European settlement when landowners required tenants through lease agreements to clear a set amount of acres per year. Over the years there have been variations in the rate of land development carried out. The amount of development has been controlled through a number of factors. During the depression and World War II when fuel was low and airstrips were sparse weed eradication was difficult. Hence, most of the Sounds area used burning as weed control resulting in fertility loss in the soil. Development in the area then moved from farming to forestry as wool and meat prices depressed, as is evident in the land use changes of Arapawa Island, Port Underwood, the Inner Pelorus and Kenepuru Sounds and Tory Channel.

Much farmland and reverting scrub has been replaced with forestry. Forestry is a land-based activity that is changing the face of the Marlborough Sounds. Exotic forests have been planted on many of the steep Marlborough Sounds hill slopes. Farming in the past has cleared the land of much natural vegetation but problems are arising with the conversion to forestry. Wilding pines are penetrating the regenerated native forest that does remain. This forest type is unique as it is the southern most point for many native species and hence a distinct forest type is present.

Forestry has influenced the coast through sedimentation from early times of land clearance in the Sounds proper, and in hinterland areas such as the Pelorus and Kaituna catchments. Forestry practises that are the most detrimental to the coastal zone occur when clearing the land to plant or when logging and transporting from the site. It is at these times that strict soil erosion and water control management must be implemented. Batter collapse and slips can occur leading to mass siltation which causes bay infilling or an increase in suspended sediment. Over time logging practises have become more environmentally friendly. However there is still room for improvement as the coast is still being adversely affected.

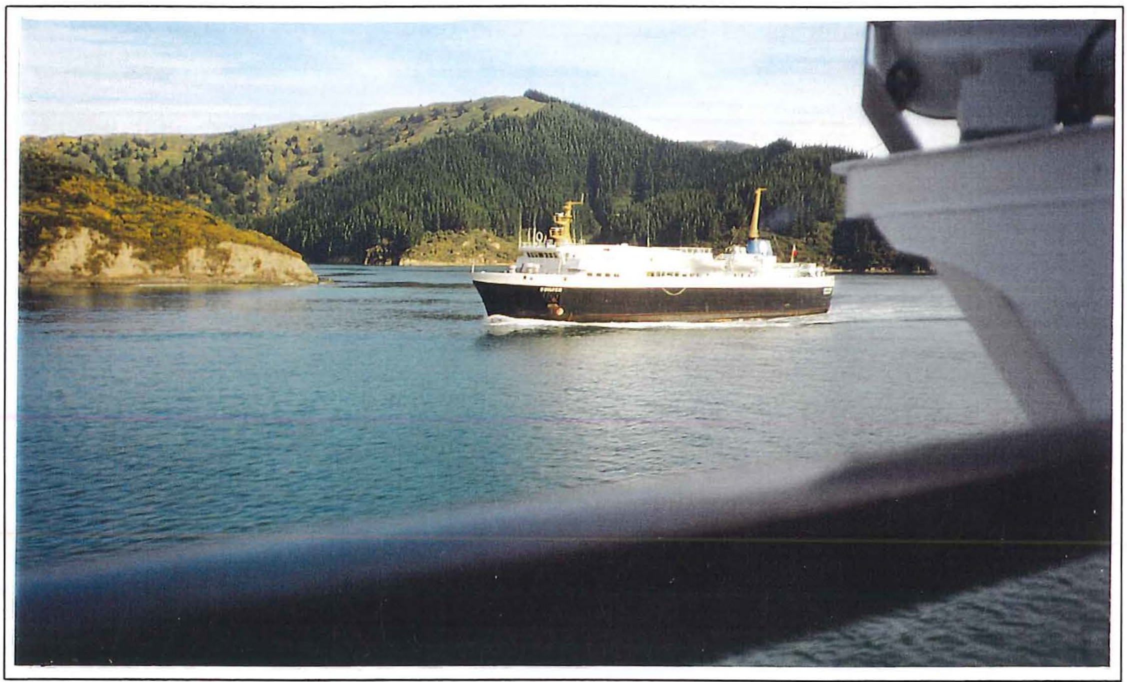
Chapter four will review the history of forestry in the Marlborough Sounds and its effects through the stages of the process of growing exotic trees, with specific reference to the effects in the coastal zone. The chapter will conclude with a brief discussion on management practises to reduce the impact of forestry to the coastal zone.

1.3 Thesis outline

The thesis will proceed initially by discussing the Marlborough Sounds area in a physical and cultural context, appreciating that both physical and human influences have formed the landscape to its current arrangement. This chapter will be followed with a discussion on the changing water uses in the Marlborough Sounds and how they have influenced the coastal zone through the addition of different wave types, with specific reference to the introduction of fast ferries to the area. Land uses will then be discussed with particular attention to forestry and its effects on changing the landscape and more specifically its influences on the coastal zone and other uses in the area. Chapter five will then discuss the forces driving landscape change in the Sounds. This chapter aims to discuss resource use in the area and the perception of resources over time. Finally the Conclusion will restate the problem and discuss outcomes from the study before putting forward some suggestions for future research.

CHAPTER TWO

The landscape of the Marlborough Sounds



A mosaic of uses of land and water in Tory Channel, Marlborough Sounds.

'Nature knows nothing of what we call landscape for Nature's scenery is the natural habitat, while our landscape is the habitat manipulated by man for his own uses. Landscape therefore is not a static background which we inhabit, but the interaction of a society and the habitat it lives in, and if either man or the habitat changes then so inevitably must the resulting landscape

Landscape = habitat + man'

Fairbrother (New Lives, New Landscape's).

2.1 Preamble

Marlborough Sounds (often referred to as 'the Sounds') are situated in the northeast of the South Island. The Sounds area is taken as the land and water bodies north of a line from Cape Soucis in the west to Rarangi in the east including all inlets and islands (Figure 2.1). The Marlborough Sounds are physiographically distinct from any other areas in the region, suggesting that it has a different geomorphic history. The Marlborough Sounds is a distinctive region having been formed by the partial submergence of river valleys. The area has land and seascapes of high scenic value where ranges of diversely vegetated hills are separated by an intricate system of land and waterways.

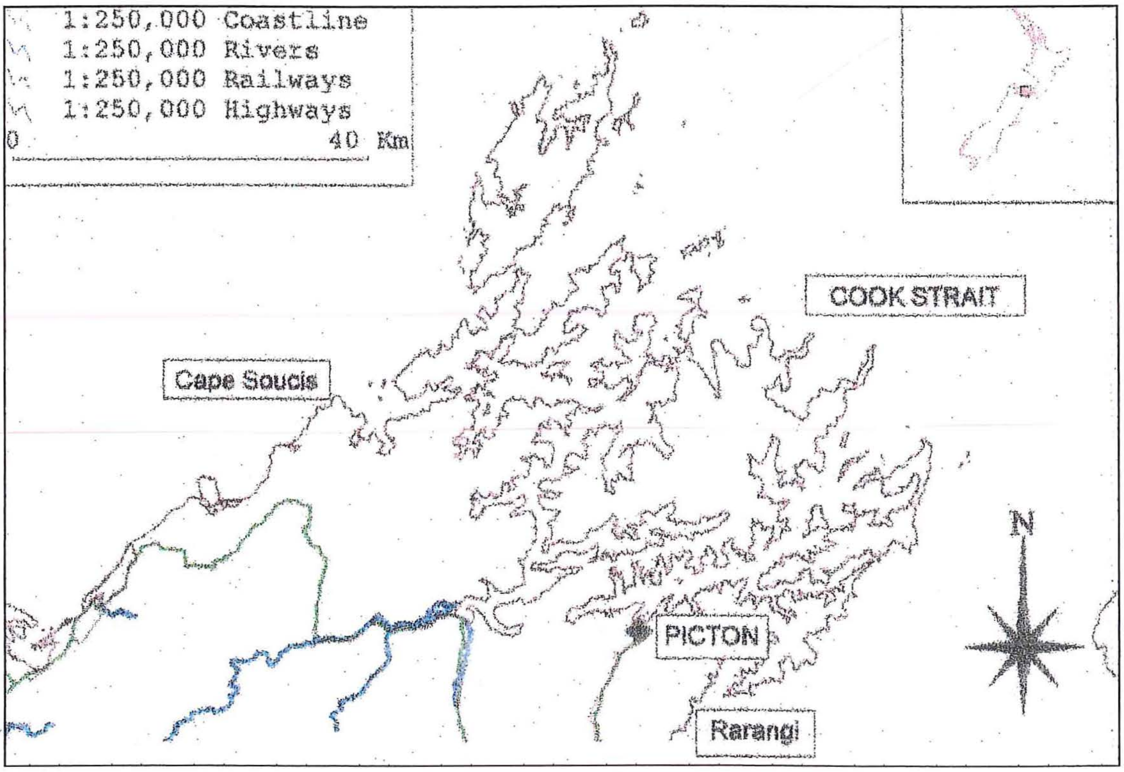


Figure 2.1: Map of the study area – The Marlborough Sounds

2.2 The physical setting

2.2.1 Geomorphology

The Marlborough Sounds is bounded by the Moutere Depression in the west and the Wairau Fault in the southeast and Cook Straight in the northeast. It has been suggested by Soons and Selby, (1992), that the block is tilting downwards towards the northeast, which probably began during the start of the Kaikoura Orogeny and led to the formation of the 23km wide Cook Strait. The downward tilting and postglacial sea level rise has led to the drowning of the river valleys to the north of the Marlborough Region (Soons and Selby, 1992). The length of this coastline subsequently is very long (approximately 336 km in Queen Charlotte Sound and 544 km in the Pelorus (Figure 2.2) (Boyce, 1971).

The Sounds comprise two major inlets, the Queen Charlotte and Pelorus Sounds, and the lesser inlets of Croisilles and Port Underwood, together with numerous islands, the two largest being D'Urville situated in the north west tip of the area and Arapawa located on the north east (Figure 2.2) (Strategy for the conservation and development of the Marlborough Sounds, 1976).

Slopes in the area are steep (rising at 30-35^{o} angles from the shoreline to a maximum height of 1205 metres at Mt Stokes) and comprise small catchments that drain into the sea. There is no point more than 10 km from a Sound, therefore the marine environment is highly sensitive to catchment landuse and hydrology changes (Sutherland, Kirk and Bell 1992, Appendix 5). Approximately 3% of the Sounds area (excluding the Pelorus and Kaituna Valleys) is flat land area (Boyce, 1971). In the outer Sounds, shores are exposed to large coastal swells and are commonly steeply cliffed and well trimmed. The ratio of land to water is outlined in Table 2.1 from Lauder (1987).

Table 2.1: Land and Water Area Ratios Summary for the enclosed Sounds modified from Lauder (1987).

	Land area (ha)	**Water area (ha)**	**Total (ha)**
Croiselles Harbour	7,745	4,225	11,970
Port Underwood	3,625	2,375	6,000
Pelorous Sound	165,180	33,400	198,580
Queen Charlotte Sound	33,340	60,605	63,945
TOTAL	Enclosed Sounds		280,495

1 Pelorus Sound
2 Queen Charlotte Sound
3 Croisilles Harbour
4 Port Underwood
5 Mahau Sound
6 Kenepuru Sound
7 Mahakipawa Sound
8 Tory Channel
9 Picton
10 Havelock
11 Waikawa
12 Shakespeare Bay
13 Arapawa Island
14 Pelorus River
15 Kaituna River
16 Kaiuma Bay
17 Nydia Bay
18 Te Awaiti Bay
19 Moioio Island
20 Ngaianui Bay
21 Bob's Bay
22 Long Beach, Grove Arm

Figure 2.2: Map of the Marlborough Sounds.

2.2.2 Geology

The principal rock type in the eastern Sounds is schist, while the central part is unmetamorphosed sedimentary equivalents (Pelorus Group sandstones and siltstones). In the western limit of the Sounds rocks are of the East Nelson Regional Sequence (mafic volcanics, serpentinites and various sedimentary types). Most rocks are indurated sandstone and siltstone, regionally metamorphosed to schist along a central axis. Valley profiles in the inner Sounds show strong asymmetry with prominent dip slopes resulting from regional schistosity (Soons and Selby, 1992).

Soils in the Sounds have been deeply weathered from their parent material. Weathering is related partly to altitude, with strongly weathered rocks near sea level and more weakly weathered rocks occurring above about 200m above sea level. This has resulted in a number of deep seated and superficial landslides through-out the Sounds that have been triggered by fault movements, coastal wave undercutting and rainfall (Laffan, 1980). Soils are acidic and leached, with a number of mineral deficiencies and have a low pH. Soils have low levels of bacteria to convert organic matter to soil, which governs nutrient availability to the plant and reflects the degree of leaching. Therefore cropping in many areas of the Sounds is limited because of the infertile soils.

2.2.3 Climate

Marlborough's weather is dominated by eastward-moving anticyclones with intervening troughs of low pressure (Pascoe, 1983). The precipitation in the area is relatively high (1000-2000mm/year) and increases to the north and west (Figure 2.3). Intense rainstorms producing more than 100 mm in 12–18 hours occur in the Sounds about once every 2–3 years (Murphy *et al*, 1991). The funnelling of Cook Strait causes an abnormal dominance of westerly weather and a constant sequence of weather changes (Pascoe, 1983). Northwest winds give heavy rainfall but rain seldom continues for more than 12 hours. Rainfall intensities of 200mm in 12 hours are not uncommon and occur at least once a year, especially in the vacinity of Mount Stokes (Sutherland *et al*, 1992). Steep rainfall gradients occur, Bowie (1963), referred to an eight hour storm in 1962 that resulted in 135 mm of rain at Havelock causing flooding of local streams.

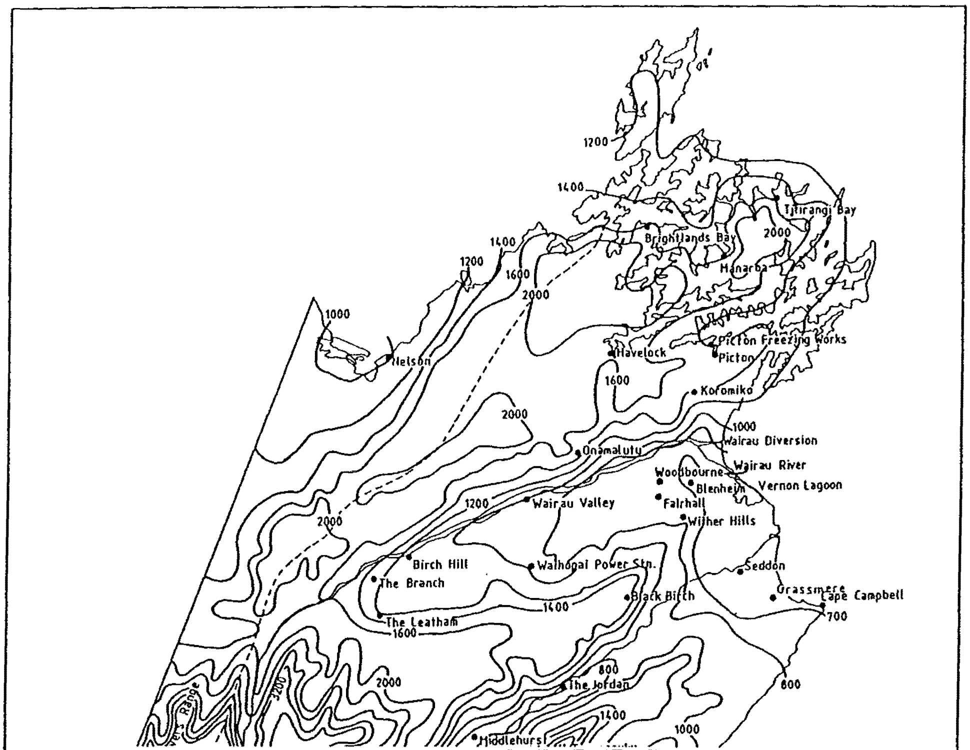


Figure 2.3: Mean annual rainfall (mm) for the Marlborough Sounds (Pascoe, 1983).

Dominant wind direction is from the Northerly quarter but topographical influences lead to large disparities in localised areas. At Picton, 89% of wind comes from the southerly and northwest and northerly winds. Winter wind velocities are low, with much greater variation in February and March. Gusts commonly exceed 28 knots, with peak wind speed present in the middle of the day (Sutherland *et al*, 1992).

Summers are warm due to the high sunshine hours in the Marlborough area (an average of 239 sunshine hours in January (Pasco, 1983, P.40)) and the winters have much variation in weather systems and temperature. Climatic extremes are dampened by the high humidity of the coastal location. Insolation in the area is high but in winter months the topography of the area leads to many sites being shaded from the sun. For example half of Te Awaiti Bay is shaded from the sun for two months of the year and more favourable places only get five hours of sunshine per day during the winter months. This decreases temperatures in many areas (Bowie, 1963).

2.2.4 Coastal landforms

The Marlborough Sounds contain 1400 km of coast (10% of the total New Zealand coast) (Sutherland *et al*, 1992, Appendix F). Boyce (1971), Newton (1977) and Lauder (1987) recognised four principal shoreline types;

- hard rock shores,
- pocket beaches,
- linear deposits, and
- bayhead or delta surfaces.

The outer coast and inner coast have generally a different appearance to the inner coast due to its proximity to high energy swells from Cook Strait.

Most beaches are pocket beaches and face the dominant fetch. Beaches range from sand through to mixed sand and gravel and cobble. Some beaches compromise more than one type within a bay. Headlands are mostly comprised of rock outcrops, rather than containing beach materials. However in some locations headlands are comprised of rocks, cobbles and boulders in foreland situations, for example, Croiselles Harbour and Clova Bay. In the inner bay, sediment is moved on and offshore through tides and waves, this process is only characteristic in shallow areas where wave energy interacts with the sea floor. In deeper coastal areas beaches can't be formed. Hence rock outcrops are present (Sutherland *et al*, 1992, Appendix F).

Most of the subtidal Sounds comprise mud substrates but the pattern is extremely diverse depending on proximity to rivers, tidal influences and wind effects. Towards the outer Sound and much of the Queen Charlotte Sound silt or clay are less prevalent. Sediment sizes on beaches can range from boulders to clay. Nearshore sediments are dominated by rubble banks, bedrock, coarse sand and shell fragments and therefore have more diverse marine communities (Rich and Shaw, 1993).

Coastal wetlands occur at the heads of the larger Sounds and arms eg, Pelorus, Queen Charlotte, Mahau and Kenepuru Sounds, Mahakipawa Arm, Croisilles Harbour and at the heads of bays such as Kaiuma and Nydia (Figure 2.2). Two or three wetland areas have been made into ports, leaving few wetlands still intact.

Major rivers such as the Pelorus and Kaituna (Figure 2.2), transport much fine sediment into the Pelorus Sound. Griffiths and Glasby (1985) estimate the total suspended sediment yield from the Pelorus River at 319,000 tonnes per year. A further 246,000 tonnes per year is contributed by other rivers into the Sounds, so that total combined sediment load per year is 565,000 tonnes per year. Thus the Pelorus Sound contrasts markedly to the Queen Charlotte Sound which has little river input. There, many of the beaches are made up of sands, rather than mud. Salinity in Queen Charlotte Sound is higher, and depths in Queen Charlotte Sound are shallower than the Pelorus Sound (averaging 35m).

2.2.5 Wave environment / tidal component

Waves in the Sounds have a number of origins, such as wind or pleasure and commercial crafts. Swell waves in the outer Sounds are generated by storms in the more open areas such as Cook Strait and Pacific Ocean. Waves are also generated by local winds. Fetch length is a major factor in the velocity and power of these winds and hence the size and energy of wind generated waves. In the inner Marlborough Sounds waves are described as low energy because fetch lengths are restricted. Newton (1977) found that in Tory Channel (Figure 2.2) wind generated waves were up to 0.25 to 0.35 metres high and wave periods were in the range of 2.0 – 2.2 seconds. Waves can on occasion reach one metre swells naturally but this happens episodically. Most bays that are west facing have higher wave energy due to the predominance of the funnelling of wind through the channels and the dominance of northwest winds.

Waves generated with a restricted fetch are characteristically steep with short periods. Oscillatory motion attenuating with depth means these waves only work on the sub-tidal part of the beach. Therefore, these waves do not have the ability to transport much sediment. Thus the bulk of sediment transport in the Sounds is accomplished by tides which are accelerated by constriction in the narrow waterways (Sutherland *et al*, 1992, Appendix F).

Boat wake waves are generated by both pleasure and commercial vessels. These waves transfer their energy from the boat to the shore and arrive at their destination at strongly oblique angles to the shore. Boat wakes work on areas of the beach that are not usually worked by natural waves. Wake heights and periods are determined by vessel speed, weight of the ship, tidal stage, and distance of the shore to the sailing line.

All types of waves shape and form the coastline of the Sounds with the aid of tides. Tides have the ability to move sediment through the actual movement of water and through the reworking of sediment at different levels of the beach or shore platform. Tides are not a major contributing factor to sediment movement in bays but in constricted channels they can gather significant velocities (approximately 3-5 knots) to be strong enough to be effective in sediment transport processes.

Tides in Queen Charlotte Sound and in Pelorus Sound are driven by different tidal systems. In Pelorus Sound the flood tide sets to the south and is related to the west coast amphidromic system, while tides in Queen Charlotte Sound are related to the east coast system where the flood tide sets to the north.

2.2.6 Flora and fauna

The natural vegetation of the Marlborough Sounds is of ecological significance as the area lies at the southernmost limit of more northerly dwelling species (such as, Kohekohe (*Dysoxylum spectabile*), Rewarewa (*Knightia excelsa*) and Maire (*Olea cunninghamii*)). Thus the Sounds vegetation is more like that of western Wellington than other areas in Marlborough or the South Island and contains the most northerly low land beech association in New Zealand. Some species present in the Marlborough Sounds acquire one of their few South Island distributions here, including Nikau (*Rhapalostylis sapida*), Ngaio (*Myoporum laetum*) and Rangiora (*Branchyglottis rangiora*). There is a high amount of endemism in subalpine shrub associations and mineral belt shrub associations, for example associations found on D'Urville Island (Bowie, 1971).

Before European inhabitance, the forest near Cook Strait and Tasman Bay was coastal broadleaf forest, while at altitudes below about 550 metres, mixed beech and podacarp predominated (Laffan and Daly, 1995), including Rimu (*Dacrydium cupressinum*) mixed with Kahikatea (*Podocarpus dacrydioides*), Totara (*Podocarpus totara*) and Miro (*Podocarpus ferrungineus*). However today most mature stands are Beech dominated with minor inclusions of other forest species as beech forest wasn't favoured for milling (Lauder, 1987).

Lack of labour during the depression and World War Two and technology (fertilizer application from the air) has caused considerable areas of the land to revert to gorse, matagouri, manuka, and tawhini. This land was kept open for pastoral activities through stocking with cattle but primarily by burning. Since the 1950's much of the Sounds did not advance technologically as well as the mainland situations and hence farms became reverted. Subsequently large areas were planted in pine forest (*Pinus radiata*).

The feral fauna on the land is dominated by introduced possums, goats, red deer and pigs. Native wildlife includes many species of sea birds, rare frogs, lizards and snails. The marine ecosystem is diverse containing urchins, scallops, starfish, paua, rock lobster, tubeworms, red and blue cod, terakihi, butterfish and snapper. Along the coasts there are large seaweeds, encrusting animals, invertebrates and many species of fish (Hunt, 1978 cited in Gardner, 1982).

Queen Charlotte Sound and the outer Pelorus Sound has much more diverse marine life. This is due to the inner Pelorus having lower light levels in the turbid water, less clean rock areas for encrusting plants and animals to settle on, and the smothering effect of silt (Johnston *et al*, 1981).

2.3 Human influences in the Sounds

2.3.1 Human history of the Sounds

Archaeological sites provide widespread evidence of early occupation by both Maori and European settlers. Throughout the Sounds, burial sites, old pa sites, evidence of shell piles and Maori ovens can be found. The area was rich in kai and many tribes inhabited and travelled to the area to use this resource. Most transport was by canoe therefore most habitation was on the coast. However walking trails were wide spread for hunting on land. There are some eight Iwi (Ngai Tahu, Ngati Apa, Ngati Koata, Ngati Kuia, Ngati Rarua, Ngati Toa, Rangitane, Te Ati Awa) who have significant cultural history in the Sounds area generally and more pertinently in specific areas.

The area was visited by early European explorers the most notable of which was Captain Cook, who visited the Sounds on all three of his visits to New Zealand (1770, 1773-74, 1777), others include Abel Tasman, D'Urville and Bellinghausen. Navigation of the channels was hazardous and many had trouble with gale force winds, reefs or tidal rips leading to many sinkings, such as the 'Edwin Fox' which is being restored and can be visited in Picton today. Other shipwrecks are popular dive areas (for example the Mikhail Lermontov in Port Gore).

The first European settlement was recorded in 1827 in Te Awaiti Bay on Arapawa Island (Figure 2.2), where a whaling station was set up. This was followed at Port Underwood with a number of other whaling stations. Picton was established in 1848 when Sir George Grey bought a large site off the Maori people. Today the Picton Area still has a large Maori population with a Marae in the Waikawa Bay area (A Strategy for the Conservation and Development of the Marlborough Sounds).

Prior to 1880 half the population of the Sounds was employed in timber milling or gold and antimony mining. Clearance of land began in the south east and inner Sounds and proceeded outwards. Stimulus for clearance of land came not from the demand for production but from the demands of new settlers for land of their own (Lauder, 1987). Over 70% of the land had been cleared by 1910 as can be seen in Figure 2.4 (Bowie, 1963 cited in Lauder, 1987).

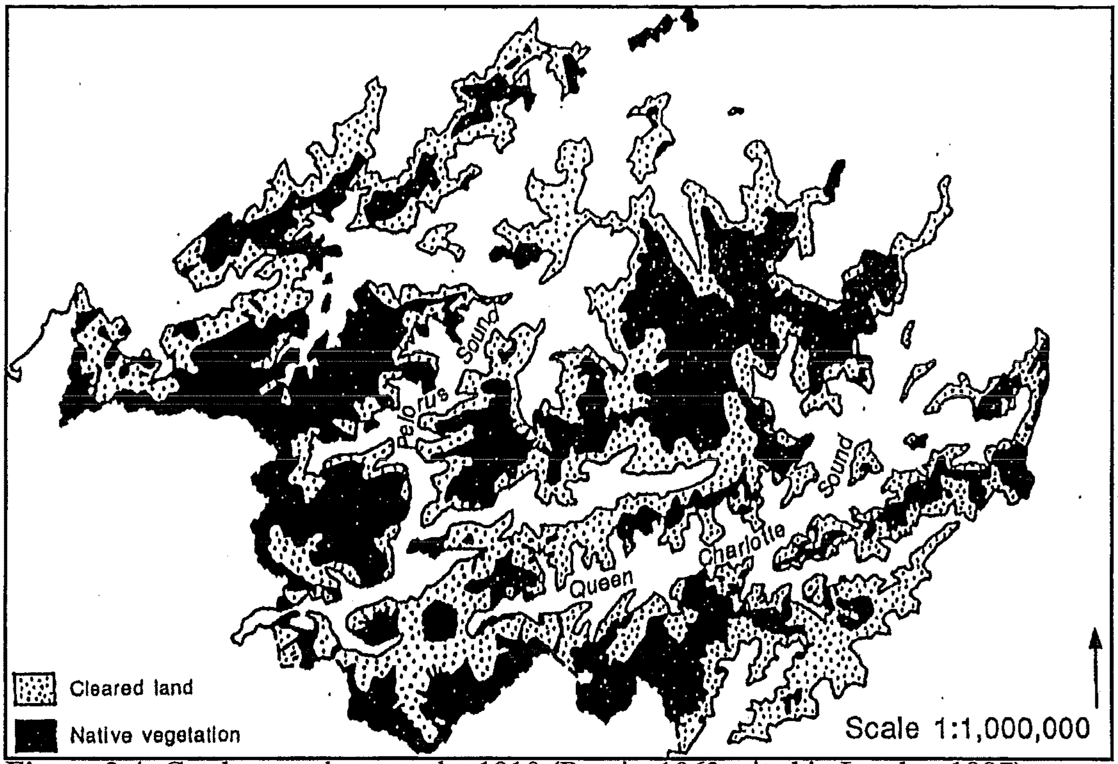


Figure 2.4: Catchment clearance by 1910 (Bowie, 1963, cited in Lauder, 1987).

Acquisition for farming then took place in the late 1870's. Farming of merino and dairy cattle predominated until the opening of the Picton freezing works in 1890 which led to running Romney and crossbred sheep for wool and fat lamb production. Farming spread to its peak in the 1910's and 1920's when 50% of the land was being used for farming. However in the 1930's depressed prices led to stock numbers decreasing, which continued at varying rates throughout this century. Farm viability was seriously affected by the high transport costs due to isolation in the outer sounds, high fertiliser costs and rising costs of land due to the growing interest in forestry and recreation in the area.

Around the 1930's some exotic forestry production was established (Farnham Forest in the Queen Charlotte Sound and small plantations in the Pelorus area) (Joint Centre for Environmental Sciences, 1980). Since the 1960's there has been an economic upsurge in forestry production and this has been reflected in the landuse of the Marlborough Sounds with more land being bought for that purpose.

Today settlements are spread throughout the Sounds. Baches are present in almost every bay. There have been a number of homes turned into home stays and some bays have been developed into resorts, camping areas or holiday units focusing on the recreational aspect of the Sounds utilisation.

Changes in transportation have aided in the upsurge of utilisation of the Marlborough Sounds for recreational purposes. The expansion of the roll on - roll off Ferry service which began in 1962 and the rapid expansion of roading in the Sounds during the 1950's and 1960's has lead to increased pressure on baches, accommodation and the demand for building sections.

The Sounds area is of great importance, scientifically, recreationally, for conservation as well as for development in the form of pastoral farming, marine farming and exotic forestry production. Some of these uses are inherently incompatible. As pressure on resources of land and water increase so does the conflict between users. The planning problem is to consider all uses and have them work in harmony. The community is working towards this aim with the proposed Marlborough Sounds Resource Management Plan where community input is reaching a conclusion towards a managed environment.

2.3.2 Uses of the area

The Marlborough region is very diverse in its land and water uses. It is a region rich in resources. The flat Wairau plains contain fertile soils that support high productivity from viticulture, horticulture and agriculture. The Sounds though, is quite a different environment to the rest of the Marlborough area although the underlying theme of production and development are ever present. The steep infertile slopes in the Sounds are not suitable for a wide variety of crops.

Subsequently, the land use in the Marlborough Sounds is restricted to exotic forestry plantation, native regenerated bush and sheep and dairy farming. In the few flat areas that are present, occupation of land is mainly residential, holiday homes, permanent residences or hospitality facilities.

Water uses in the Sounds are significant. The ports of Havelock and Picton provide services for boaties to fish recreationally or commercially. Mussel harvesting boats and commercial fishing vessels are also common. Table 2.2 shows the boat numbers in major marinas in the Sounds. However this does not account for sites in other bays (for example Elaine Bay, French Pass and Port Underwood) which also have heavy use whether for recreational weekend use or for commercial boat use. Boat use is highly variable between Sounds, at different times of the year or week. Summer is busier than winter and during the weekends boat use is higher than weekdays.

Table 2.2: Boat numbers in the three main marinas in the Sounds.

Port	**Boat storage type**	**Number**
Picton	Marina	173
	Boatshed	70
Waikawa	Marina	570
	Boatshed	37
	Compounds	150
	Moorings	200
Havelock	Marina	268
	Boatsheds	85
	Compound	44
TOTAL:		1597

Many cruise liners enter the Sounds area, usually through Queen Charlotte Sound. Chartered boat use is popular as well as a raft of sports such as water-skiing, jet-skiing and kayaking. Transport across the Cook Strait through Tory Channel by fast ferry or conventional ferry and other freight traffic such as the Suilven, links the North Island with the mainland, and leads to heavy boat traffic in Queen Charlotte Sound and Tory Channel.

Water use has also increased with the development of the mussel industry. This industry has grown bigger in the last few years with the lifting of the moratorium on mussel farms. As a result mussel farms are becoming more common as are the boats that service them. Scattered throughout the Sounds, the evidence of mussel farms are the mussel buoys floating on top of the water. Salmon farms are less numerous but are also a water use in the Sounds.

2.3.3 Human influences

Human modification of the Marlborough Sounds, like most other areas of New Zealand has been significant. There are few landscapes in the Sounds that have had no human effect. The human influences started with land clearance and building. Today development has moved from subsistence to sustainable utilisation of resources with little consideration for the future of the area or its enchanting drawcard for so many tourists. People flock to the Sounds to "get back to nature", failing to see what is so clear to the trained eye as a hugely modified landscape which although aesthetically pleasing, is not "natural".

Human influences in the area congregate mainly in the two main town centres, Picton and Havelock (Figure 2.2), both of which are small and depend on the larger towns of Blenheim and Nelson for supplies. Population statistics are outlined in Table 2.3.

Talbe 2.3: Population statistics for Marlborough Sound areas from the 1996 census.

Grouping of 1996 Census Districts	Population
Marlborough Sounds Coastal Marine	86
Marlborough Sounds Terrestrial	3206
Picton	3061
Waikawa	843
Havelock	503
Total Marlborough Region	38,397

At the head of Queen Charlotte Sound the overseas port and the Cook Strait ferry terminal of Picton is situated, which has links to major centres through State Highway One and the main trunk railway. There is a deep water Port at Shakespeare Bay (Figure 2.2) that has recently been built to aid in the export of goods such as timber and coal.

Over the last twenty years or so, there has been an economic change in the Sounds, with the development of marine farming, expansion of exotic afforestation and an increase in recreational uses and tourism, development of ports and marinas, residential subdivision and roading. In 1972 the recreational significance of the Sounds was officially recognised with the establishment of the Marlborough Sounds Maritime Park. Since a change in government policy the land administered by the crown covers approximately 30% of the land area including an almost continuous foreshore reserve (Joint Centre for Environmental Sciences, 1980). While economic development is occurring in the Sounds there is still a strong recognition of the need to conserve areas.

2.3.4 Management of the Sounds

The Marlborough Sounds is governed by both the Marlborough District Council and the Department of Conservation governs the foreshore reserve and any other conservation reserves in the area. Most activities are controlled under the Resource Management Act (1991) by these authorities. The Resource Management Act (1991) replaces more than 20 major statutes including the Town and Country Planning Act, 1977, water and soil legislation and the laws covering minerals, geothermal resources, air and noise pollution and coasts. The purpose of the act is to promote sustainable management of natural and physical resources. Sustainable management is defined in the Act as,

> 'managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well being, and for their health and safety..., while:
>
> - sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonable foreseeable needs of future generations
> - safeguarding the life-supporting capacity of air, water, soil and ecosystems
> - avoiding, remedying, or mitigating any adverse effects of activities on the environment.'

The purpose of the Resource Management Act (1991), recognises that people need to use resources for their welfare, but in doing so compromise the ability of the environment to continue to provide those resources, or other indirect services (such as erosion control) to the community (Ministry of Environment, 1997).

Section 6 of the Resource Management Act (1991) states that the Act must recognise and provide for resource issues of national importance. Natural and Physical resources are specified including the coastal environment, protection of significant vegetation habitats, protection of outstanding features and landscapes, public access, and the recognition of Maori cultural values in terms of land and water (Henderson and de Lambert, no date given). All of these resources are important in the context of the

Marlborough Sounds and therefore management of the area requires strict adherence to Section 6.

The Resource Management Act (1991) is an 'effects' based legislation rather than controlling the activity itself as has been done in the past. This provides incentives for resource users to come up with efficient and creative ways of achieving good environmental standards and gives local authorities greater flexibility in how they can achieve environmental goals. The Act has a large community focus with the public's right to propose changes to plans and enforcement procedures. It also considers conservation areas, fisheries and iwi resources when decisions are made (Ministry of Forestry, 1994).

Regional and District Councils (Marlborough Area has a unitary authority, that is, it has both territorial and regional government responsibilities), enforce regulations and monitor effects on various resource use activities through consultative processes and a hieratical system outlined in Figure 2.5. This involves the community and other interested parties in the forming of policies. Integrated management of both natural and physical resources is the desired outcome of the Resource Management Act and this is obtained through regional policy statements (Ministry of Environment, 1997).

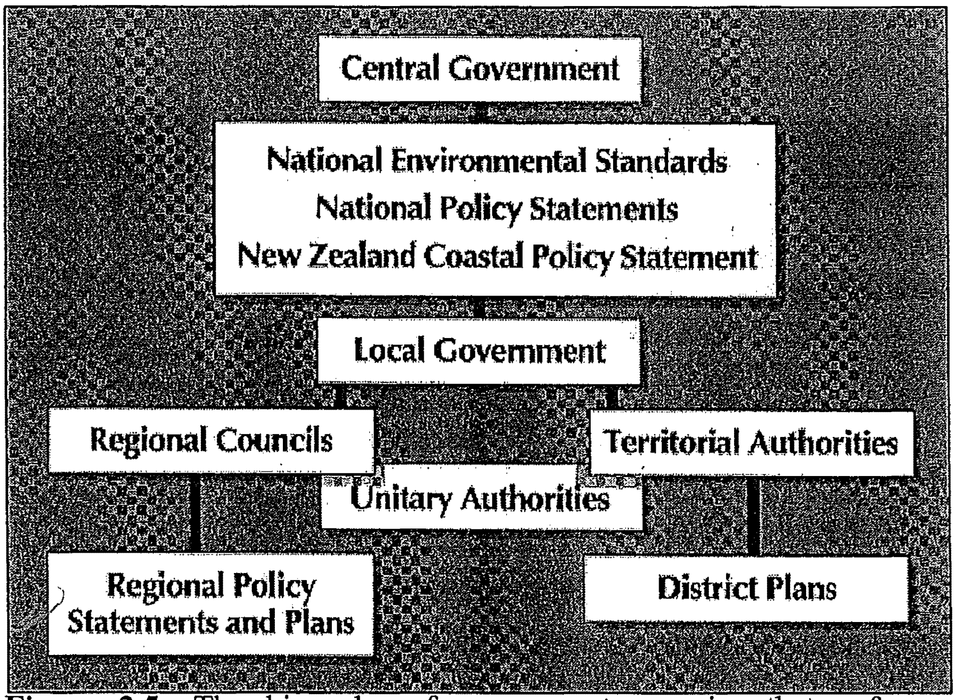


Figure 2.5: The hierarchy of government agencies that enforce the Resource Management Act (1991) (Ministry for the Environment, 1993).

The coastal environment is recognised in the Resource Management Act (1991) as an area with management needs beyond the usual requirements for sustainable management. Section 6 is applicable to the management of coasts,

> '(a) The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development'.

Regional Coastal Plans are compulsory for all regions in New Zealand. They are formulated by the Marlborough District Council and the Department of Conservation and must be approved by the Minister of Conservation. Policies in the regional coastal plans apply to activities in the Coastal Marine Area, that is the foreshore, seabed, coastal water and the air space above, between the Mean High Water Springs (MHWS – the line of the average of the high spring tides) to the limits of New Zealands territorial waters (12 nautical miles). The Marlborough District Council is a unitary authority and the area has a Regional Plan which encompasses both their District and Coastal Plans.

The Environment 2010 Strategy (released October, 1994) was produced to complement the governments economic growth strategy (June 1993). The aim of the Environmental 2010 Strategy is to help focus the priority effort and act as an umbrella for Resource Management, and hence give long term direction to environmental policies (Ministry of Environment 1997). New Zealand law is realising the importance of identifying resources and managing them effectively, and this is highlighted in the importance the Resource Management Act (1991) holds in the judicial system.

2.4 Summary

This chapter has introduced the location of the study area. Both physical and human aspects of the Marlborough Sounds have combined to form the area today. Physically, the geomorphic features of the Sounds drowned river valleys provide the backdrop to the Sounds landscape. Overlaid on this physical base are the human influences that have moulded the Sounds into a mosaic of land and water uses. Uses of the area have changed over time as resources in the area have been realised and infrastructure in the region has aided the economic viability of development.

It has been identified that the landscape has changed over the years from natural bush to the mosaic of forestry, grazing, marine farms, recreation and residential use that forms the landscape today. The landscape of the Marlborough Sounds is ever changing as both development and conservation of areas is still going on today. This chapter has aimed to put the Marlborough Sounds situation in context of how the landscape has changed from both natural and human induced forces and discussed how the area is managed today under the Resource Management Act (1991).

The following chapter will address the issue of fast ferries and their part in changing the landscape of the Marlborough Sounds. Fast ferries are both an economic and social resource in the Marlborough Sounds but they are having both actual and perceived effects on the Ferry Corridor both environmentally and endangering some peoples safety.

CHAPTER 3

Fast ferries and their effects on the Marlborough Sounds

The 'Lynx' fast ferry service, Tory Channel, Marlborough Sounds.

'The shattered water made a misty din. Great waves looked over others coming in,

And thought of doing something to the shore. That water never did to land before'.

Robert Frost, 1874-1963

'Once by the Pacific'

3.1 Introduction

This chapter aims to discuss the introduction of fast ferries into the Marlborough Sounds and the subsequent effects on the Sounds with specific reference to the effects on the coastal zone. As the public's attention has primarily been drawn to conditions near the coast, the investigation is concentrated on wake wash in the coastal areas. Management strategies used to decrease effects of the fast ferries will also be discussed. The 'fast ferry problem' will be addressed at a local level. However, it is also an international issue, with complaints of wake wash problems from fast ferries near river banks, coasts and in harbours in Sweden, Ireland, Australia, England, Portugal and the United States.

The ferry issue in the Marlborough Sounds is a political, emotional and highly volatile subject among many locals in the Marlborough Region. Bach and house owners in the Sounds are generally of the view that the fast ferries are ruining the unique picturesque environment and changing the use of both water ways and coastal areas in the ferry corridor. Others claim the fast ferries are of national importance and are a key link between the two islands, therefore they are a necessity. They argue that the economic significance of the ferries is great and that a new equilibrium of beaches will be reached in response to the changing environment of ferry waves. This issue is not new in the Marlborough Sounds. There was much public outcry when the conventional ferries came into service in 1962 and in 1977 with the introduction of new vessels (Newton, 1977). However over time this level of disturbance has become publicly acceptable. At this point in time, the level of disturbance from fast ferries is unacceptable in the public's eye and therefore the issue is a contentious one.

This chapter aims to discus the resource of the sea transport link between the North and South Island. This resource is heavily utilised and has had increased demand with the technological expansion through the introduction of fast ferries to the region. This resource is changing the landscape of the Marlborough Sounds by increasing the boat traffic utilising the shipping channel through Queen Charlotte Sound and Tory Channel. It is also changing the wave environment and use of some areas due to the wake produced by the fast vessels.

3.2 History of ferries in the Marlborough Sounds

There is a long history of rail ferries and large commercial boats using the Tory Channel entrance into Picton as a major transport route into the South Island. The route from Picton to Wellington through Tory Channel and Queen Charlotte Sound has been used for ferries and other commercial shipping vessels since at least 1925 (when the first regular ferry operation commenced). Picton is the closest port to the North Island and is the gateway to state highway one (the main road south) and rail link to the cities of both Christchurch and Dunedin. The introduction of a roll on roll off rail, road and passenger ferry service in 1962, between Wellington and Picton, has been one of the most significant events in New Zealand's transport history. It has changed the way New Zealanders travel within the country. The traditional kiwi summer holiday, moving to less populated areas with campervan in tow has been extended so New Zealanders can discover outside their backyard and head across the Strait. The cost efficiency of this type of travel for both people and freight has led to popularity of the service.

The demand on the ferry service has always been steady. Over the summer periods, bookings on the ferry became essential as it was the most affordable way to cross the Strait. The regular, reliable service and the facility to take motor vehicles won the ferry services popularity with both New Zealanders and International Tourists alike. Popularity became so great that New Zealand Rail (the owner/operator of the ferries) decided to diversify and modernise the service to suit customer demands. The choice to diversify did not come early. In 1995 it was 70 years since the 'Tamahine' was commissioned into what was the first dedicated Picton/Wellington service at the service speed of 15 knots. The 'Arahura' traverses Tory Channel at 20 knots. In no other sector of transport has speed increased so slowly in that time (Marlborough Express, 30/1/95, P.1).

In the summer of 1994 – 1995 two fast ferries began service between Picton and Wellington through Tory Channel. These vessels were operated by New Zealand Rail and Sea Shuttles New Zealand Limited and offered a voyage of under 2 hours (substantially shorter than the conventional three and a half hour voyage). The Sea Shuttles New Zealand Ltd service lasted only one season due largely to unreliability of their vessel ('Albayzin') due to engine trouble. Tranz Rail's 'Condor 10' was a twin hulled catamaran that was capable of carrying in excess of 500 passengers and 82 motor vehicles and travelled at speeds of 37-38 knots. In November 1995 a fast ferry service between Mana and Picton called the 'Straitrunner' began operation but was under liquidation by April the next year (Munro, 1997). Later in 1997 'Topcat', a 96 metre fast ferry provided an efficient, economical, year round, inter-island service. With a cruising speed of up to 42 knots, the crossing takes under 100 minutes. 'Topcat' can accommodate up to 580 passengers and 240 vehicles. 'Topcat' along with New Zealand Rails' Lynx service has been operating through Tory Channel and Cook Straight ever since. Both boats produce similar wave trains and their waves have similar effects on the coastal zone.

It is only in recent years that the design of fast ferries has progressed to the stage where they can be viable in conditions such as those prevailing in Cook Strait, even though they had been talked about by the rail company since 1979 (Rails, 1995). The 'wave piercing' hull design of the fast ferries has meant that they can travel in the rough waters of Cook Strait. A catamaran ('Condor 10') was chosen to make the fast crossing for the first season of operation. This was chosen over the monohull ('Albayzin') which was chartered by Brook McKenzie and dubbed "Sea Shuttle". The monohull had the same speed and capacity as 'Condor 10' however the catamaran was chosen due to its low fuel cost to speed ratio and its comfort to passengers. The Tranz Rail boat ('Condor 10') has a desirable hull shape with two-sharply pointed cylindrical hulls for stability and manoeuvrability, which carry revenue-earning space above them, clear of disturbances on the water. Low weight Aluminium (instead of steel) was used and computer-controlled stabiliser systems were used to improve the sea-keeping qualities in more exposed waters of Cook Strait (Rails, 1995). Plates 3.1 and 3.2 show examples of both a conventional and fast ferry.

Plate 3.1: Conventional ferry coming into Picton harbour.

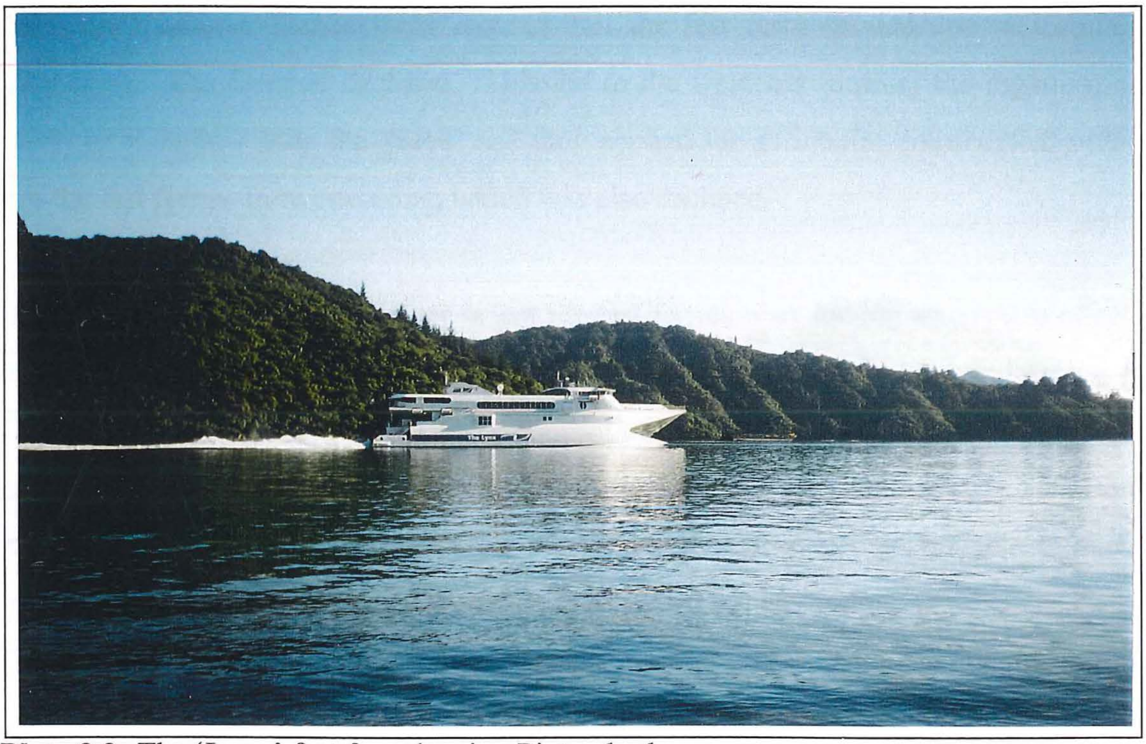


Plate 3.2: The 'Lynx' fast ferry leaving Picton harbour.

The fast ferries do have limiting factors though. They do not travel when wave height in Cook Straight exceeds four metres (van Wingaarden, 15.02.1999), whereas the slower ferries can travel in higher wave heights of five metres (however this also depends on wind). Fast ferries cannot travel at night for reasons of navigational safety, limiting the number of crossings that can be undertaken each day.

The introduction of the fast ferries was not all smooth sailing. A Planning Tribunal hearing sought an enforcement order to slow the speed of fast ferries in the Marlborough Sounds. This hearing was between a local organisation, 'Save the Sounds - Stop the Wash' and Te Atiawa Manawhenua Ki Te Tou Ihu Trust ('Te Atiawa') and the ferry companies, and was undertaken in December 1995. This followed the local residents of the Sounds noticing changes which were described as erosion, destruction of marine life, washing up of large boulders onto the shore, disturbance of ancient burial grounds, potential damage to moored boats and structures (eg. jetties and boat sheds) and danger to individuals. Residents approached the Marlborough District Council, which had primary regulatory authority under the Resource Management Act, to halt the fast ferry service due to its alleged destruction. The Council declined. This led to the residents forming the organisation – 'Save the Sounds – Stop the Wash' and they applied for an interim enforcement order to stop the fast ferries from operating, which was also declined.

The tribunal read evidence whether or not the fast ferries were having an adverse effect on the environment, in particular the coastal area, and whether the ferries were in keeping with the Resource Management Acts (1991) concept of sustainable management. The outcome of this case was won by the defendants, New Zealand Rail as there was insufficient evidence that the activity was noxious, dangerous, offensive or objectionable to such as extent that it has or is likely to have adverse effect on the environment (Kós *et al.* 1995). The Tribunal also concluded that the Cook Strait Ferry Service is one of 'national importance and should not be the subject of a cessation order on the basis of the inconclusive and subjective evidence' (Kós *et al.* 1995). The effects of the fast ferries were found not to warrant intervention.

It was also argued by New Zealand Rail that the ferry services both fast and slow are a service of national importance. It was put on behalf of New Zealand Rail during the course of the hearing:

> 'No more futile gesture could be imagined than setting a nations face against advances in transportation technology. Faster and larger capacity planes and boats are an inevitability – because of the public quest for efficiency in transportation. To turn a fast ferry into a fast-fast-slow ferry is a foolish fox-trot. The same recessional tune would leave us with coal smoke belching, counter-sterned ferries like the 'Tamahine' and cloth-covered open cockpitted Tiger Moths' (Kós and Bielby, 1995).

Opponents of the ferries argued that fast ferry companies should have to get a consent and this would involve an assessment of environmental effects. The only existing controls on ferries were the speed limits entering or leaving Ports and navigational controls under the Harbours Act. Nothing was included in the Resource Management Act pertaining to shipping so the ferries did not need consent. Tory Channel has always been a navigation route and ferries an existing use. Fast ferries were considered to have the same or similar effects to the conventional ferries before they were introduced so both the Department of Conservation and the Marlborough District Council said they did not require any consent. The Marlborough District Council now has a Regional Coastal Plan (as part of the Marlborough Sounds Resource Management Plan) which makes the existing ferry route a 'national shipping route" on which all commercial shipping is a permitted activity.

The proceedings focused mainly on s21(1) of the Resource management Act, which states,

> 'No person may, in the coastal marine area-
>
> (c) disturb any foreshore or sea-bed (including by excavating, drilling or tunnelling) in a manner which has or is likely to have an adverse effect on the foreshore or seabed…; or…
>
> (e) destroy, damage or disturb any foreshore or seabed … in a manner that has or is likely to have an adverse effect on plants or animals or their habitat;…

unless expressly allowed by a rule in a regional coastal plan and in any relevant proposed regional coastal plan or a resource consent'.

3.3 The issue today

Today, the fast ferry issue is still volatile. Locals feel they have been hard done by with the decision not to restrict the speed of the fast ferry service. There is a feeling that the big companies win because they have the money to keep fighting and the "little guys" (private bach owners) end up the victims. Many locals spent a lot of money in the hearing process as did Tranz Rail, Sea Shuttles New Zealand Ltd, and to a lesser extent Marlborough District Council and the Department of Conservation.

'Save the Sounds - Stop the Wash' (STS) is still a prominent organisation in keeping tabs on the ferry service. Media coverage is the main form of advertising their cause. Statements by Peter Beech, the head of the organisation today often appear in the Marlborough Express or Christchurch Press, showing readers examples of alleged destruction by fast ferries, or the danger of the waves that they produce. Often these articles are somewhat biased, showing the largest wave in a set, at spring high tides, at an area close to the sailing line. An example of this can be seen in Plate 3.3, which shows a photograph of a fast ferry produced wave at high tide that was printed in The Press. Plate 3.4 shows the same property with a fast ferry generated wave at low tide hitting the sea wall. This wave is considerably less impressive. As a result, many people who haven't themselves witnessed the ferry wake consider the wake to be near catastrophic all the time and are in support of a need to slow down the fast ferries. A letter from Michael Fowler to the Marlborough Express (18.09.2000, P.4) put forward some interesting evidence about the sea wall that had been allegedly damaged from fast ferry wave action. He found from Council that the wall had no council approval whatsoever. 'It was built without engineering advice, and fell over'. The Council or owner have made no attempt to publicise this fact.

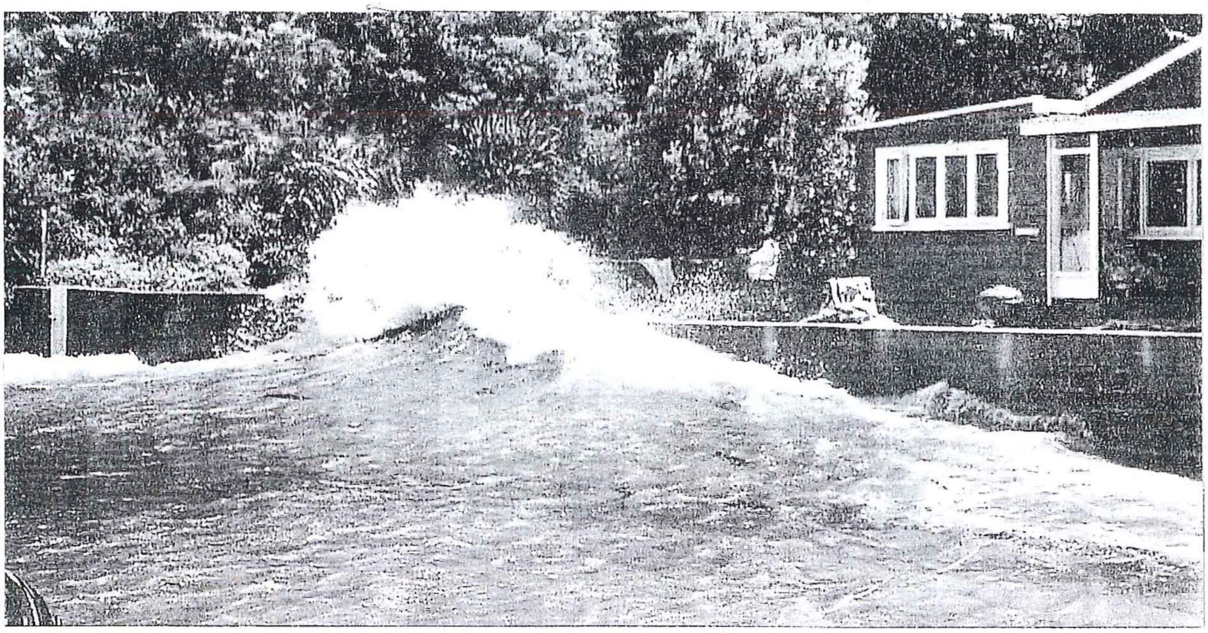


Plate 3.3: A fast ferry wave hitting a sea-wall in Maraetai Bay at high tide (The Press, 10.05.2000, P.1).

Plate 3.4: A fast ferry wave hitting the sea wall in Maraetai Bay, at low tide.

The negative response to the fast ferries from many locals may have been overcome if the fast ferry companies voiced their concerns or comments to some of the issues that were put forward by the Sounds residents. This approach may have educated the public to a wider view of the situation.

Consequently the Marlborough District Council has backed the locals and feels pressure to come to some sort of resolution. With large public outcry stating the speed of the fast ferries is too fast and the wake is a danger to people on the beach, the Council have acted to propose a speed by-law. This bylaw is designed to address maritime vessel speed, to reduce the risk of collision and effects of wake/wash (Marlborough District Council, 06.07,2000). The bylaw came about through pressure from the public to do something about controlling the fast ferry speed.

A decision to slow fast ferries could influence the local economy and subsequently affect the popularity vote for councillors to be reinstated. If the ferries were to be slowed, the convenience of the speed of fast ferry service would be lost. The Lynx service has reduced the return crossings from 3 to 2 per day, in anticipation of the bylaws introduction (The Press, 29.07.2000). This may effect Marlborough's economy as there would be less people coming over for day trips due to time constraints with a longer service. No one is prepared to pay the extra and use the fast ferry service if it is not going to be fast. Tax payer money may also be used up frivolously as such a restriction is likely to be appealed by the fast ferry companies.

The bylaw proposed by the Marlborough District Council is flawed. Firstly it is proposed for fast ferries only. Other large vessels can produce large wakes without the regulation applying to them. It will mean that the slow ferries will be over taking the fast ferries as the slow move at a speed of up to 24 knots while the fast ferries will be restricted to 18 knots. Secondly, the bylaw is based on a Danish formula that is used in Danish waters that are quite different to the Marlborough Sounds. There has been no work done to show how the 'Danish rule' relates to the Marlborough Sounds.

Thirdly, there has been no clarification by the Marlborough District Council of what aspects of waves and their behaviour affect safety. For example the negative perception towards the safety of fast ferry generated waves posed by some users of the area is that the long, low waves are dangerous to people on the beach because they come unexpectedly and have quite a strong draw back. However these waves are not a danger to small boat craft. If the wave train produced by fast ferries was modified so that the wave produced was higher and shorter it would be a danger to a small vessel. However this wave would have a small runup on the beach and be more safe for users of this area. The bylaw does not explain what wave type is appropriate to increase safety in the Ferry Corridor. The bylaw does not explain what is meant by safety, nor discuss how the bylaw adds to safety of people utilising the coast. Public perception of fast ferry waves has been influential in the management of the high speed vessels in the Marlborough Sounds. However addressing these perceptions has its pitfalls as perceptions have not always been based on fact.

To reduce wave height at the beach the bylaw proposes to slow the ferries down. Wave height is influenced by a number of factors including distance to shore, weight or loading of the vehicle and vessel speed through the water. The bylaw states that wave height produced by the ferries must be recorded at a depth of 3 metres. Reasons for this depth are not explained. However, it would assume that at approximately this depth, small vessels may have safety problems with waves overturning vessels. This water depth has no correlation with the wave height or period at the beach. Three metres water depth can occur at 100 metres offshore or two metres offshore, hence location will control on the changing wave shape as it interacts with bottom bed morphologies closer to the coast. A major concern from residents and users of the Sounds was that fast ferry waves pose a danger to those using the foreshore, yet wave runup and power at the beach is not dealt with in the Councils speed bylaw.

The bylaw states:

> 'The Council must not only be fair but be seen to be fair with no reasonable perception by any person that anyone making a decision has predetermined the issue'

(Navigation and Safety in Tory Channel and Queen Charlotte Sound and Queen Charlotte Sound – HO90-07 in section 4(1)). This is an important statement which must be taken seriously by council. By instigating this bylaw two fast ferries may be out of business, travellers will be inconvenienced with longer travelling times and income of the area may reduce. This outcome certainly isn't 'fair' to both parties. With the removal of fast ferries from the ferry corridor another beach equilibrium will evolve. This may result in many Sounds beaches eroding without the influence of the accretional long period waves that are produced by the fast ferries.

In the memorandum an accredited expert is defined as

> 'a person or organisation whose views the Harbourmaster will respect for certain technical purposes associated with the Bylaw. The Harbourmaster will in due course name such persons. Any person who would wish to be accredited would be able to ask the harbourmaster for accreditation and the Harbourmaster would make a decision depending on the qualifications and experience of the applicant'.

This leaves the Harbourmaster in a position of much control. He decides who is accredited or not and decides what information the Council should receive. It is important to have accredited scientists so you know the information you are receiving is correct. However, having all this onus on one person could be dangerous if the accredited experts all had one biased view.

3.4 The nature of boat wake waves

In the ferry corridor waves at the beach are generated by a number of processes. These include natural wind waves, private boats, freight carriers, cruise liners and ferries, both conventional and fast. When considering shoreline change, none of the above wave types can be considered in isolation from each other. All wave types combine to form the wave regime present in the inner Queen Charlotte Sound and Tory Channel. The water resource of the channel is heavily utilised. With the introduction of fast ferries the occurrence of high energy, human made waves has increased thus changing the wave regime incident at the coast.

Waves are the principal catalyst for change on beaches. They move sediment on and offshore as well as laterally along the coast. The beaches dissipate this energy with the weakest materials known to man – a combination of water and sand. While human made engineering structures will crumble over time from the constant bombardment of waves and tides the natural beach can stand its ground.

Whether a wave erodes or accretes a coast depends largely on wave shape. Wave height is defined as the distance between trough and crest and the period is the time taken for successive crests or troughs to pass. Wave steepness is a measure of wave shape and can be calculated by dividing the wave height by the wave length. In general steep waves erode beaches while flat waves accrete. Accretion and erosion are also dependent on wave power and the size and shape of the beach sediment material.

Boat wakes are a part of the wave environment reaching the shores of Tory Channel and Queen Charlotte Sound and produce waves of significant magnitude relative to wind generated waves. These waves are influenced by a number of vessel and environmental related characteristics. These are outlined by Parnell (1996, P.3) in Table 3.1.

Table 3.1: Factors influencing ferry wake characteristics at a site (Parnell, 1996, P.3).

Vessel related	**Environmental**	**Other**
Speed	Tide level	Distance from sailing line
Course	Tidal stream direction	Wake interactions
Loading	Wind wave characteristics	Location of recording site
Timing	Tidal stream velocity	
Speed through water	Coastal morphology/ topography and bathymetry	
Speed over ground	Water depth	
Ballasting	Sediment characteristics	

When a ship moves through the water a system of waves will typically be generated from the ship's bow, from the foremost and sternmost shoulder and from the ship's stern. Waves arise as a consequence of pressure differences along the ship's hull when the ship makes headway. In deep water, the wave pattern consists of diverging waves (spread on either side of the ship at an acute angle to the ships sailing direction) and transverse waves (waves that travel in the same direction as the ship). This is illustrated in Figure 3.1 (Sorensen, 1973).

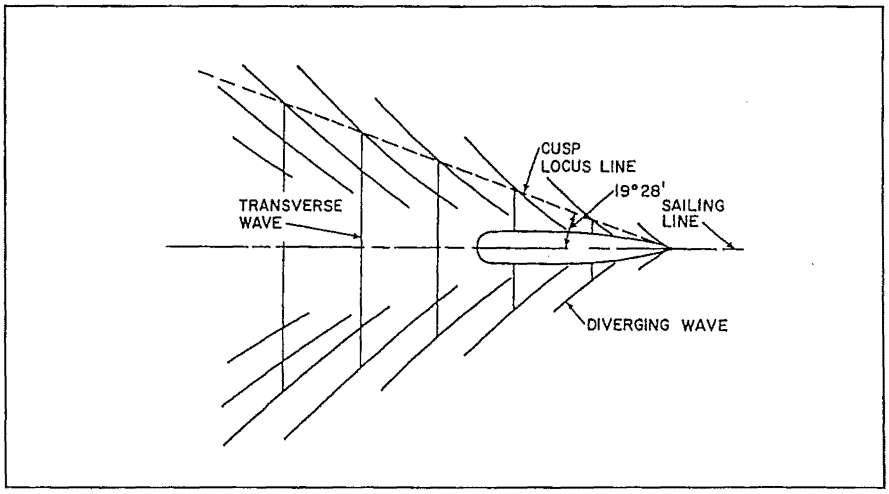


Figure 3.1: Deep water wave crest pattern generated by a ships bow (Sorensen, 1973, P.248).

Lord Kelvin in 1886 found in deep water the two wave trains intercept along the cusp locus on both sides of the ship. This line is 19.47° from the sailing direction. The wave crest is at an angle of 54.73° with the navigational route. Propagation (c) and period (T) of these waves can be calculated by $c=0.42V_s$ and $T=0.27V_s$ respectively, where V_s is the ships speed in knots. This theory is good for determining wave length, propagation and angle of propagation but can not be used for describing the height of generated waves (Danish Marine Authority, 1996).

Configuration and characteristics of vessel generated waves have been developed to form a wide body of literature on the topic (for example, Froude, 1977; Kelvin, 1887; Havelock, 1908, 1931, 1932, 1935; Sorensen, 1967, 1968, 1969, 1973; Schofield 1974). Boat waves have been studied extensively in relation to navigatable waterways and confined waterways (for example, Whittaker *et al*, 2000; Hey, 1968; Feldtmann, 1997; The maritime coastguard agency, 1988).

In New Zealand very little research on boat wake waves has been undertaken. Literature began with Newton's (1977) work on the 'Sedimentary Dynamics of Tory Channel'. Later, more work has been completed in the Marlborough Sounds with the introduction of fast ferries. Both the Marlborough District Council and Tranz Rail have undertaken monitoring programs of beach change and wave process in the Ferry Corridor. This literature has been added to by Ash (1997), who looked at 'Morphodynamics of Tory Channel Beaches as a Result of Seasonal Artificial Wave Action'. Work by Pickrill (1978) and Kirk (1989) on the effects of boat wakes on the shoreline of Lake Manapouri has increased the knowledge on boat wake waves effect on sheltered shores. Boak (1996) has looked at the effects of vessel generated waves in Torpedo Bay, Auckland. This body of literature is small but has been useful in determining effects of boat waves on the coastal zone in this study.

Wave generation in deep water may be characterised by the 'depth' Froude number and the 'length' Froude number. The formula proposed for medium to low depth is

$$\text{Froude Number} = \frac{Vs}{\sqrt{g.d}}$$

(where V_s is the speed of the ship, g is the acceleration due to gravity and d is the water depth). The vessels wave train is strongly influenced by water depth. When a ship moves in water of medium or low depth, the ship generated wave pattern will be different from the pattern that some ships will form in deep water (Froude number (Fn_h) >0.6-0.7). In general it is said that in shallow or deep water, when a ship sails at a sub-critical speed, $Fn_h < 1$ (but in practise lies slightly less that one), critical speed is when $Fn_h = 1$ and super-critical speed is when $Fn_h > 1$. Largest wakes are generated close to the critical speed. Studies by the Danish Hydraulic Institute (1998) at Hobart, Tasmania, found that vessels with lower service speeds generated higher waves as these ferries were operating closer to critical speeds. Critical speed (Froude number between 0.8 and 1.25) should be avoided. Overseas studies have used this Froude number equation as the basis for predicting wake wash height and period in shallow water (Kofoed-Hansen *et al*, 1999). This formula however is not suitable for the deep waters of the Marlborough Sounds.

Fast ferries typically generate a wave pattern consisting of groups of both short periodic and long periodic waves. The long waves are not observed out at sea due to the low steepness of the waves but it is this wave type that usually causes problems in shallow waters and near the coast. The height of the long fast ferry wave increases due to shoaling as the water depth decreases. Simultaneously the wave length decreases and the steepness of the wave increases to a point where the wave breaks (Danish Maritime Authority, 1996). Waves of a long period propagate considerably faster than the short periodic waves produced by other boats, therefore arrive at the coast more quickly. This can cause some danger to people on the coast who do not have time to move from the beach or nearshore in a boat.

Figure 3.2 and 3.3 (Single, 1999b) show graphically the wave trains of both a conventional and fast ferry. Figure 3.2 shows the fast ferries characteristic draw down of the water level followed by the first wave being of a large height. In this wave train there are two groups of large waves at the start of the wave train, waves decrease in height as the wave train progresses. The conventional ferry wake shown in Figure 3.3 differs in that this wave train does not have an initial draw down like the fast ferry. The largest wave has a similar wave height to the fast ferry of 0.9 metres (as shown in Figure 3.2). The conventional ferries have a set of waves of relatively large height followed by a series of low waves, then another set of larger waves which tapper off. However wave trains are highly variable in height and period depending on factors such as the tide, speed, and distance from the sailing line.

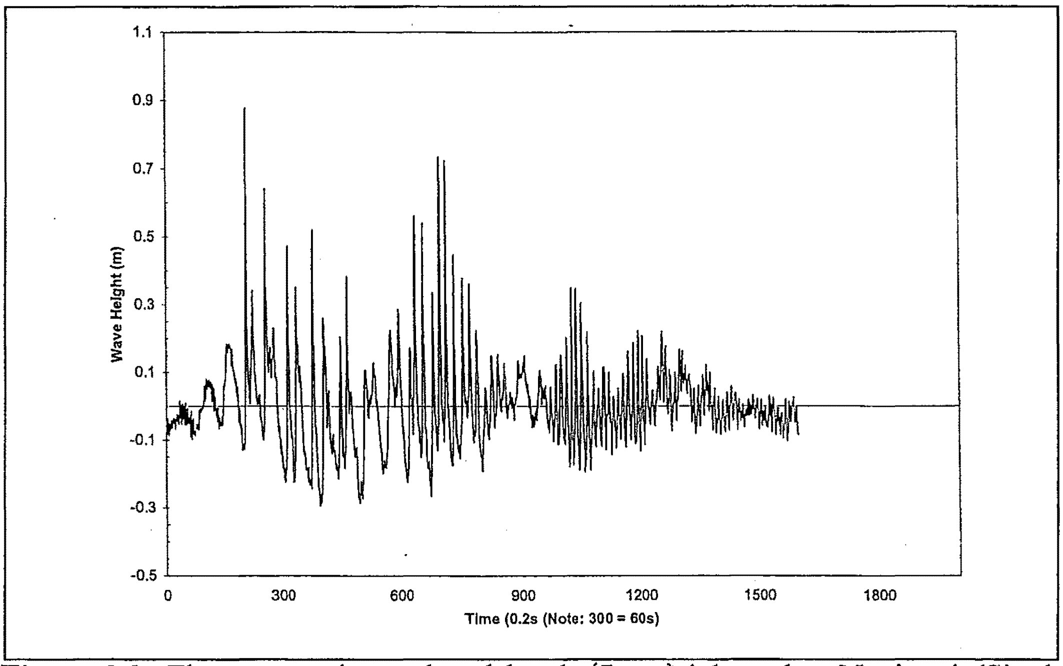


Figure 3.2: The wave train produced by the 'Lynx', inbound at Ngaianui (Single, 1999b, P.10).

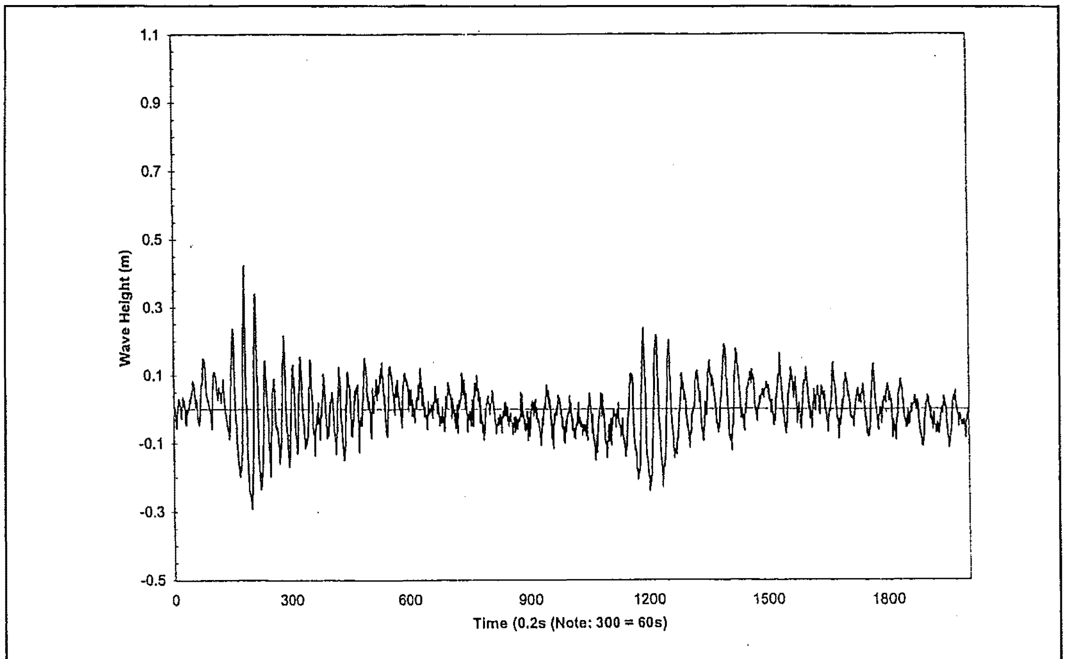


Figure 3.3: The wave train produced by the 'Aratere', inbound at Te Iro Bay (Single, 1999b, P.4).

Passing of two vehicles at high speed in a relatively narrow channel can lead to the transverse stern waves of the two vessels superimposing. This substantially increases both the water level drawdown and the current effects on the channel beaches. It has been found by Kirkegaard *et al.* (1998) that wave height decreases as you move away from the navigation track (Figure 3.4). Newton (1977) found that areas further than 1000 metres from the sailing line were relatively unaffected by conventional ferry waves due to distance decay of the energy in the wake wave.

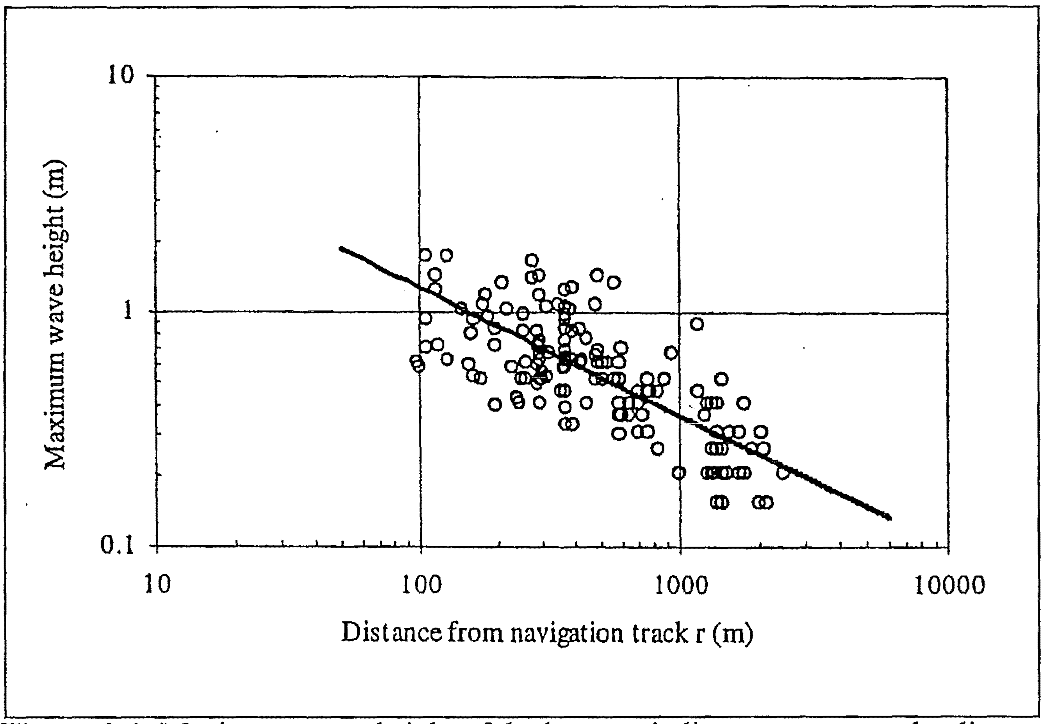
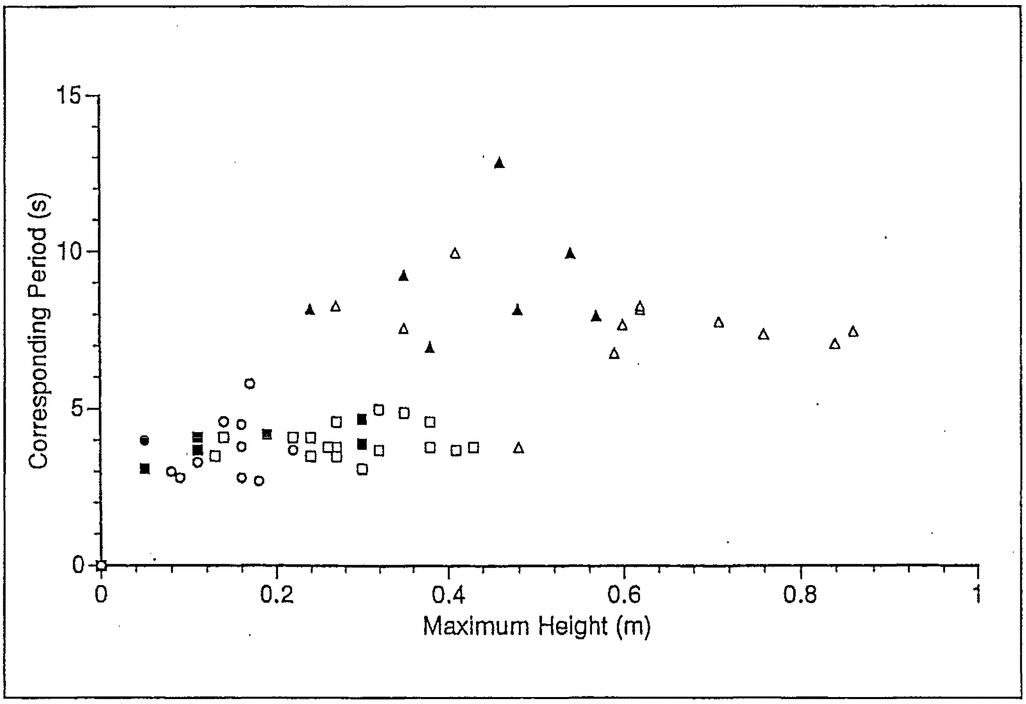


Figure 3.4: Maximum wave height of the long-periodic waves versus the distance from the ship track (Kirkegaard *et al.* 1998, P.5).

Waves from fast ferries distinguish themselves significantly from waves generated by conventional ferries in that they have a much longer period. Conventional ferries have a period of between four and five seconds where as a fast ferry produces a wave with double that period (approximately eight to twelve seconds). For a given wave height, wave run-up increases with increasing wave period (Croad, 1995). Croad's (1995) results for wave period were shorter than that of Parnell (1996) who found the average wave period for 'Condor 10' was 8.11 seconds and for the conventional ferries 3.8 seconds (both Croad and Parnells recordings for this data were taken offshore using S4DW's). Parnells (1996) findings are shown graphically in Figure 3.5. Both conventional and fast ferry wakes produce a wave train with different heights and periods throughout one wake event. Thus an average period does not address the period of the highest or lowest wave of the wake event.



Key: ■= conventional ▲= fast ● = other

Figure 3.5: Parnells (1996, P.9) showing maximum height and period of fast and conventional waves.

Conventional ferries have higher wave steepness compared to the fast ferries. Waves of higher steepness are generally erosional compared to those of lower steepness, which are accretional. A characteristic feature of the fast ferry wakes is shown in Plate 3.6, which shows the long draw back that appears immediately before the first (and often the biggest) wave arrives at the coast and is due to the proceeding trough of the wave. These long period waves propagate faster than the wake produced by conventional ferries and therefore arrive at the coast much faster.

Data have shown that the severity of the wake wash increases with the load condition of the vessel (Danish Hydraulic Institute, 1998). This is especially the case during acceleration. When the fast ferries in the Marlborough Sounds carry a lot of freight and trucks, the ship sits lower in the water and produces far larger waves than when carrying lighter loads. Acceleration is controlled by a speed restriction in Picton harbour (being 12 knots harbourward of Mable Island).

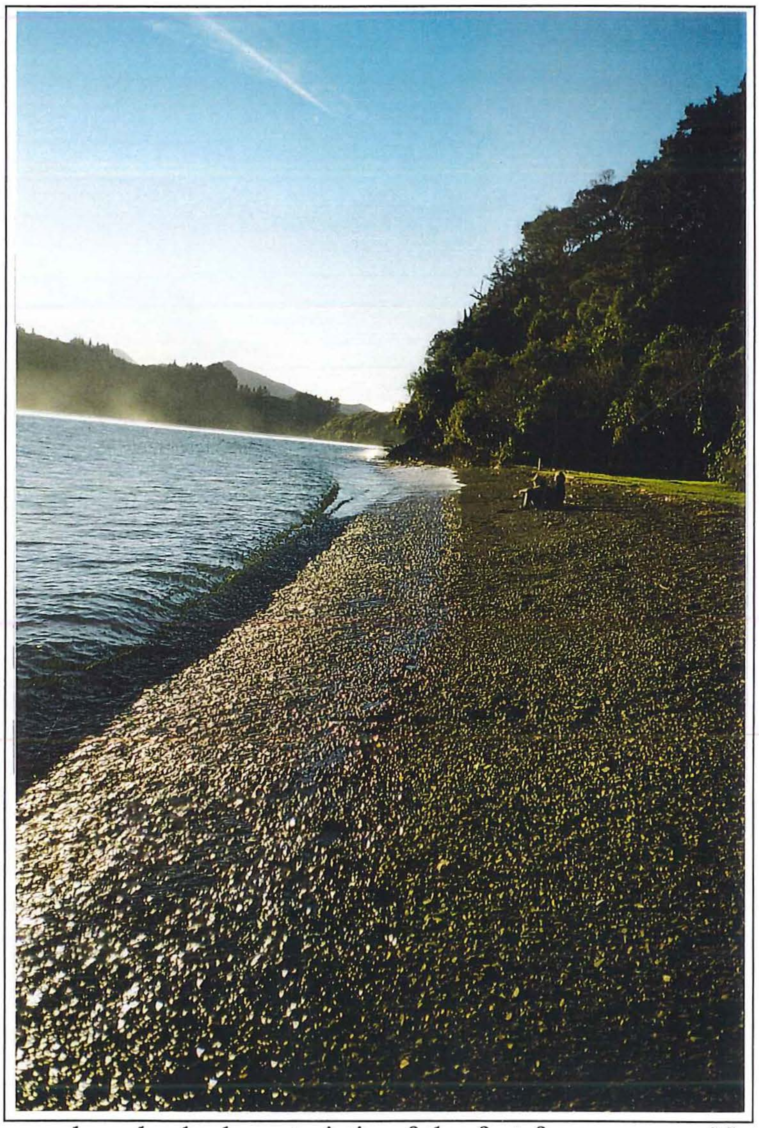


Plate 3.5: Long draw back characteristic of the fast ferry waves. Note the wet beach line showing the water level before the first wave.

Boat wake waves can approach the coast at different angles to natural waves. Plate 3.6 shows the wake produced from a small inboard water taxi. This photograph was taken towards the direction of greatest fetch. The waves approach the shore at an oblique angle and are initiating long shore transport in the bay. The aspect of the beach to wave approach is different for boat wakes than wind waves due to the angle of the ships path and hence its wave train to the bay. The waves are working sediment from a different direction than naturally formed waves.

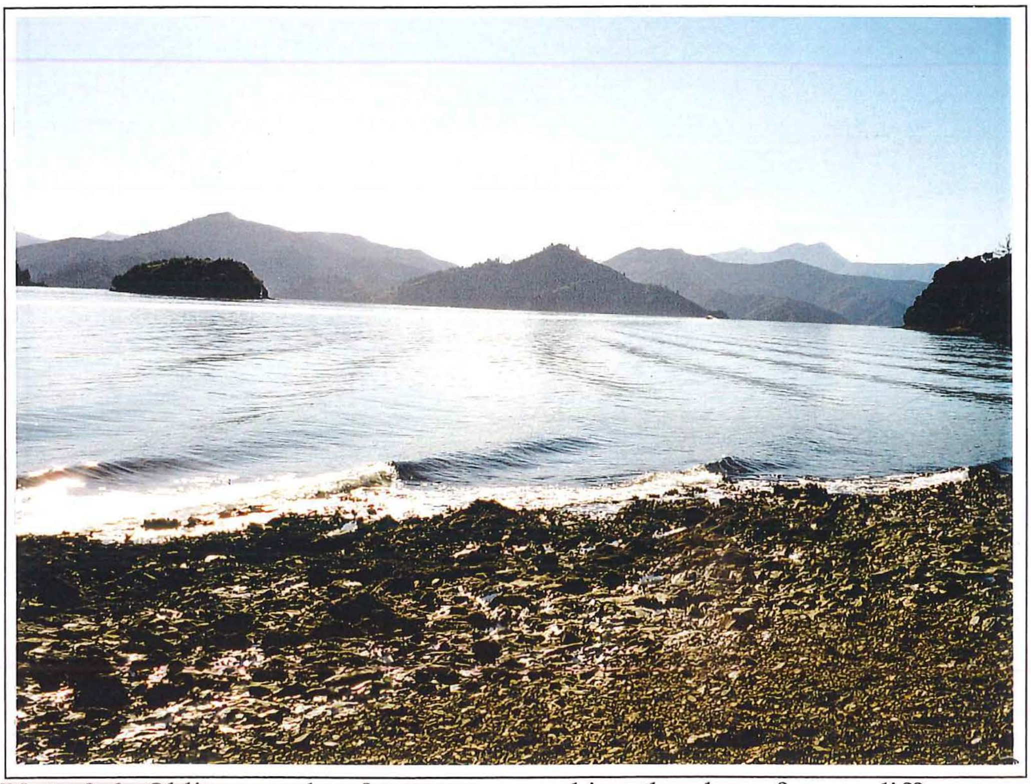


Plate 3.6: Oblique angle of waves approaching the shore from a different angle than the dominant fetch. (Waves produced from a small inboard water taxi).

The relationship between fast ferry wake and the processes operating on the shore is often not obvious. Wave parameters that may affect erosion include, wave runup, wave energy, wave steepness and wave power. At the planning tribunal hearing, parties presenting submissions based most of their evidence on the relationship between wave steepness and erosion or accretion. It has been argued by some scientists that this is not an appropriate correlation (Parnell, 1996). However, all current models of beach erosion and accretion include a wave steepness criterion. Parnell (1996) used velocity of near bed water movement to determine sediment movement. This methodology is largely based on Hjustrom's curve (Figure 3.6).

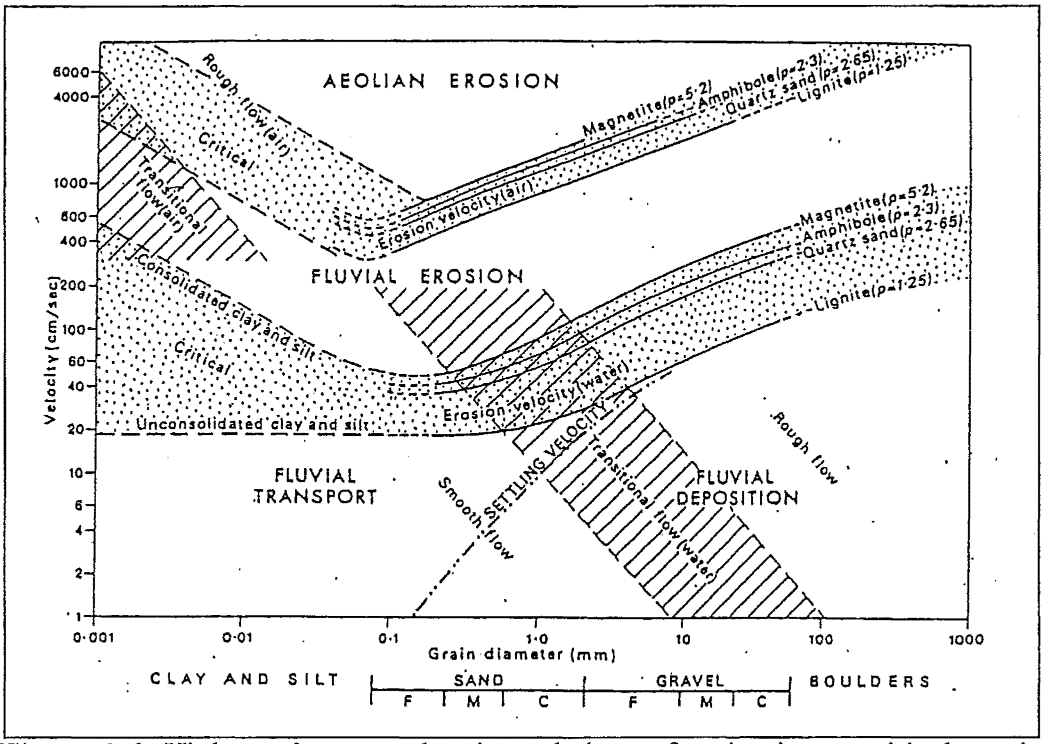


Figure 3.6: Hjulstrom's curve showing relations of grain size to critical erosion velocity (after Sundberg, 1956 cited in Parnell, 1996, P.12).

The material on the sea bed moves landward and seaward during each wave. This movement is often asymmetrical and controls whether the sediment is transported onshore or offshore. Sediment is transported more easily when maintained in motion, it is difficult to initiate motion, although with larger sediment sizes this difference becomes smaller. Velocity of the water is an indication of the potential to move sediment. The final factor is the shape of the particle being transported. Flat particles are difficult to move initially but have a slow settling time as the large surface area to volume ratio aids in transportation. Spherical particles are more easily rolled along the bed, but tend to stop moving at higher current velocities than flatter particles of the same size.

Parnell's (1996) data showed that wave velocities from fast ferries had the potential to transport material up to and including small boulders, particularly of the shape characteristic of the local schist. His work suggested that sediment movement could be transported more frequently and further (offshore, landward or laterally along the beach) with the fast ferries, than with the water velocity produced by the conventional ferries.

3.5 Effects caused by the introduction of fast ferries

Wake waves have been incident on Marlborough Sounds shores for many years. They have over time become more frequent with the increase in boat traffic and waves have changed in characteristics so as to have different effects on the shoreline. However although waves are the predominant cause of shoreline change they are not the only factor that changes the coast in the Sounds. High rainfall and steep slopes, combined with weak colluvial soils lead to many landslides in the area. This process replenishes the coast with sediment but also leads to coastline retreat. Forestry practises and land clearance for farming also change the sediment budget of beaches, by affecting slope stability during logging and this leads to sediment input to the coast. Shoreline works such as seawalls, groynes and jetties, that are present in the Ferry corridor can also change beach processes in the area. Single and Kirk (1995) suggest that Tory Channel is a busy transport seaway, and its adjacent hinterland has undergone change both naturally and by humans. Therefore the coast and its agent of change (wave action) cannot be characterised as natural. Hence the 'natural' condition of the Marlborough Sounds beaches is not an issue because the area is no longer in its natural or even near natural state.

3.5.1 Effects on Flora and Fauna

Plate 3.7 shows Te Awaiti Bay (Figure 2.2) and an accumulation of weed prevalent after the introduction of the first fast ferries in 1994/1995. This weed covered the beach and caused bad odours attracting flies and making it unattractive to users of the beach. This bay is a historic whaling site and it was claimed that tourism was being affected by the weed (Marlborough Express, 12/1/95, P.3). This area now has no weed present suggesting that some of the effects of the fast ferries may be only short term and that the accumulation was not solely caused by fast ferries. This perhaps supports the idea put forward at the tribunal hearing that initially change to the coastal system may be severe but over time the beach and the ecosystem therein would form a new equilibrium.

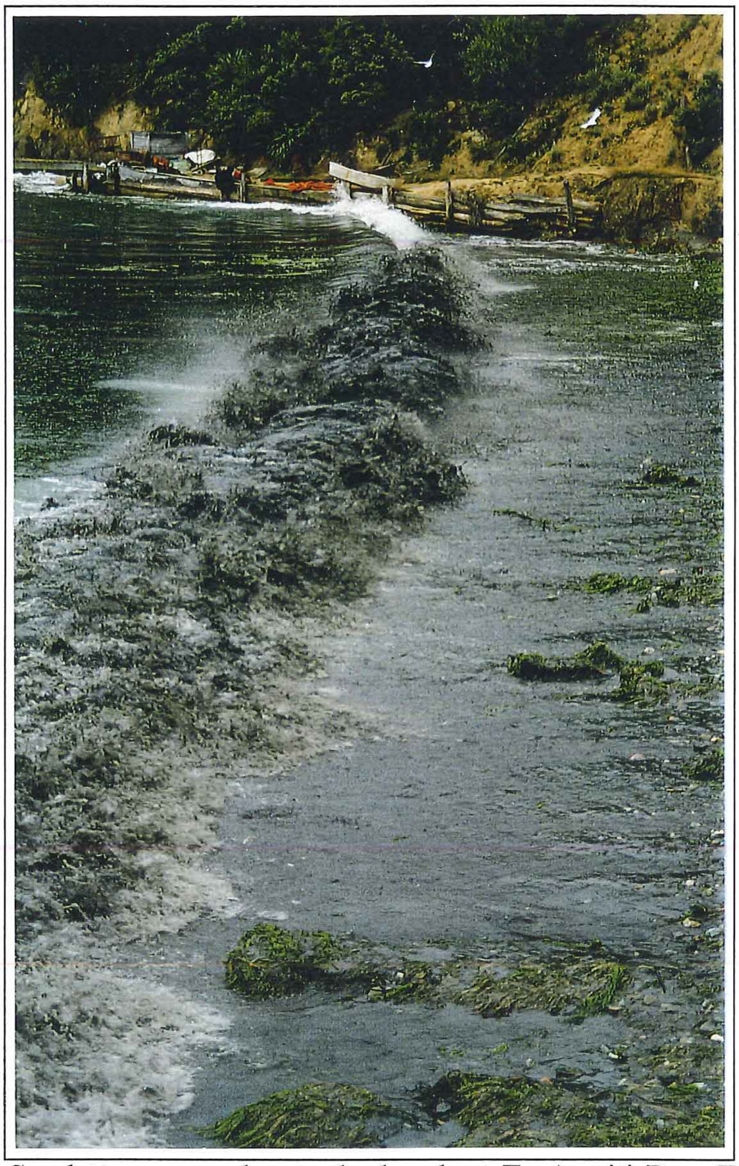


Plate 3.7: Sea lettuce moved onto the beach at Te Awaiti Bay, Tory Channel during the first season of fast ferry service in the Marlborough Sounds.

There is often a lot of suspended sediment in the nearshore after and during the wave train from ferries interacting with the beach and shallow bay materials. Data on water turbidity in the ferry corridor has not been obtained to the authors knowledge. Increased sediment levels in the water could have detrimental effects on fish and fauna as less light is available for photosynthesis. The amount of suspended sediment near the coast depends on water depth, the availability of fine sediment and energy imparted to the water by each boat movement. Both fast and conventional ferries can increase turbidity at the shore. The result of increased turbidity is not a long term problem and sediment in bays seems to settle relatively quickly after the ferry has passed. Work has been done on suspended sand concentration events due to shoaled waves over a flat bed (Dick, Erdman and Hanes, 1994) and in shallow rivers (Hilton and Phillips, 1982; Gerrad and Hey, 1987) with very site specific results. The presence of fine sediments in the nearshore depends also on supply of this sediment from hill slopes and catchments. An increase in both suspended sediment and fine sediment on the sea floor occurs after a major rainstorm and slips, until it is removed to deeper water by wave and current action. That is waves disturb fine sediment but something else provides it.

Effects on fauna have been claimed. A paper by Davidson (1995), commissioned by DoC to study disturbance to the ecology of the Tory Channel Area, found that all sites monitored showed evidence of recent disturbance. Levels of disturbance depended on shore aspect and location in Tory Channel. Disturbance was described as relocation of substrata leading to the mortality of flora and fauna. A total of seven species of algae and 24 species of invertebrate were recorded dead in the intertidal and shallow subtidal zones. Mortality appeared to be as a result of relocation from their natural habitat or from physical damage. Burial or smothering of shore fauna was also observed. This was observed when the fast ferries were in their first season of operation. There can be little doubt that the fast ferries have changed the ecology of the coastal area due to the energy of fast ferry waves to move sediment at a greater rate and of a greater size, influencing many flora and fauna. It is claimed that the fast ferries have greatly increased these effects to fauna but due to the large quantity of boat traffic, producing waves that interact with animals habitats in Tory Channel, it is not only the fast ferries that have contributed to such a low amount of animal life in the Ferry corridor.

There has also been reports of effects to inner sound dwelling animals that live under rocks, since the fast ferry service began. There is an apparent decrease in the quantity of these animals and their population structure. This change has taken place over a long time frame since the introduction of regular fast ferries. There is a large area effected by the ferry wake therefore there has been a big impact (Rob Davidson, *pers com*, 15/2/00).

It has been claimed by some that the fast ferries have had an effect on the local fishing industry. Fishing has reduced in the Tory Channel area but fish numbers have decreased steadily for well over 10 years. There has been no data produced concerning the relationship between the introduction of fast ferries with the number of commercial fish species. This claim is somewhat unfounded. It is interesting to note that the Marlborough Express reported good fishing in Queen Charlotte Sound in an article published on the 11.12.1999, P.4. The lack of fish, if any, is more likely due to overfishing in the area than to the introduction of fast ferries. There has however been a reduction in the amount of seaweed in the last few years resulting in a decrease in paua as this is its main food source. This also may or may not be attributed to fast ferries, highlighting the need for data in verifying cause and effect.

3.5.2 Effects to peoples safety

In sheltered coastal areas like the Marlborough Sounds, where local wind waves have relatively low energy most of the time, bathers or recreational users of the coast are often taken by surprise by the larger waves from ships. The surprise element can occur when the ship waves reach the shore some time after the ship has passed the locality.

A controversial risk assessment produced for the Marlborough District Council by an Australian firm Risk and Reliability Associates claimed that once a year the fast- ferry wash could be expected to overturn a small craft. There was also the possibility of a death every four to five years (Marlborough Express 9/03/00, P.1). The report has been criticised by the Maritime Safety Authority (cited in the Marlborough Express 9/03/00, P.1) to be shallow and without sufficient evidence to reach firm conclusions. In the last 5 years there have been no reports of serious injury nor deaths. This type of study is difficult to carry out as boat numbers and accident occurrences have not been accurately recorded.

3.5.3 Effect to culturally significant sites

The last occupiers of Moioio Island (Figure 2.2), the Te Atiawa tribe, departed the island 150 years ago after the death of its chief Huriwhenua in 1845. His body was buried on the island, which became tapu and later a historic site. At the top of the island, cooking and storage pits, hollows where warriors once slept, carved terraces and scattered greywacke rocks used for cooking and grinding food can be found (The Press, 11/3/00, P.2). A landslide on the north east side of Moioio Island has been present for many years (well before the introduction of fast ferries). Retreat has continued due to the nature of the geology, destabilised vegetation and exposure to wave action. However, it is claimed that the rate of retreat of the landslide has accelerated and threatened burial grounds at the top of the island. This claim has not been substantiated with evidence. There is no survey data of the landslide before of after fast ferries. The beach monitoring program from Tranz Rail shows accretion of the beach beside the slide, this may be being nourished from the landslide material but no study has been undertaken to model sediment movement.

At Bobs Bay (Figure 2.2) archaeological material has been lost since the site was last inspected in 1997. Of particular concern to iwi was the disturbance of human bone (koiwi) at burial sites as a result of erosion (Marlborough Express, 23/3/00, P10). This site was invaded by Te Rauparaha in 1828. The Rangitane people then living on Karaka Point were invaded by Te Rauparaha and nearly all the occupants were killed and eaten. This site has been eroding for some time and is continuing to do so. Additional areas where human bone has been disturbed are at Eliza and Keenan Bays and Kaihinu Beach in Te Weu Weu Bay (Riwaka, 1995). In most cases the bones have been found on the beach as a result of hill slopes slipping onto beach areas, and the unconsolidated material being eroded by waves.

3.5.4 Effects on the Marlborough economy

The economic effects of fast ferries are difficult to quantify. If the ferries were to stop operation, Port Marlborough's revenue would be substantially decreased. A Marlborough Express article (10/3/00, P.1) claims that Port Marlborough has a record financial performance in the half year to December 1999, with revenue up by nine percent and a thirteen percent profit increase. The company has declared a higher interim dividend of $875,000. Of the annual dividend council receives $1.5 million a year and of that $1.1 million subsidises rates across the whole district. The remaining $400 000 is used to fund special projects such as the Picton Sewage Scheme (Marlborough Express, 10/3/00, P.1).

The Port funds the Marlborough community substantially and any losses to the Port will almost directly affect the people of Marlborough.

The council is presently undertaking a cost-benefit analysis of the impact of the Cook Straight fast ferries on Marlborough (Marlborough Express, 20/03/00. P.1) which is as yet not completed. The council recognises the importance of the commercial ferry operations to Marlborough's economy, but the benefits must be balanced against the long-term environmental cost of their operation and the preservation of safety standards in the Sounds. The ferries bring many people to the Marlborough area for short day trips and Marlborough residents utilise the service for day trips to Wellington. Local businesses rely on this turn-over especially in the winter off season.

3.5.5 Effect on moored boats

Effects on moored boats from ship waves have not been investigated in the Marlborough Sounds but has been investigated by Kurata and Oka (1984) for shallow waterways. They found that the response of the moored vessel depended on the maximum height and period of vessel wakes passing the mooring. This could be calculated by an examination of Froude numbers for particular vessels. They suggested a speed of 10 knots or less through navigational channels to have no significant effect on small cargo ships. There has been no such study undertaken in the enclosed ferry corridor in the Marlborough Sounds. Boats of pleasure craft size in the Tory Channel area must not be tied to a jetty when ferries pass by, as wake waves could cause damage to the outside of the boat from bashing against the jetties. This has severely changed the use of the area for some Sounds dwellers. They must take their boat off the jetty on every fast ferry sailing and often for conventional ferry sailings to protect it from certain damage.

3.6 Effects of fast ferries on the coastal zone

3.6.1 Experts perspective of the effect of fast ferries on the coastal zone

Wake wash events are markedly different from waves generated by conventional ships. With the introduction of the ferry services a significant input of wave energy to the existing wave regime resulted. More energy meant that there was a greater potential for waves to move sediment. The different wake energies can be seen visually in Plates 3.8 and 3.9 and graphically in Figure 3.7. Figure 3.7 suggests that the maximum wave in both 'Condor 10' and the conventional ferries wake event is similar in energy. However in a whole wake event the energy at the beach is greater for fast ferries than conventional ferries. On shore transport of material during fast ferry waves occurs due to the orbital motion exceeding a critical value leading to initiation of bedload transport. The run-up height is higher for long-period waves generated by ships than natural waves of the same height. This will result in the swash zone of the beach getting wider and higher due to the new wave environment of the introduced boats (Kirkegaard *et al.* 1998).

Plate 3.8: Wake from a Conventional ferry, Bob's Bay, Queen Charlotte Sound.

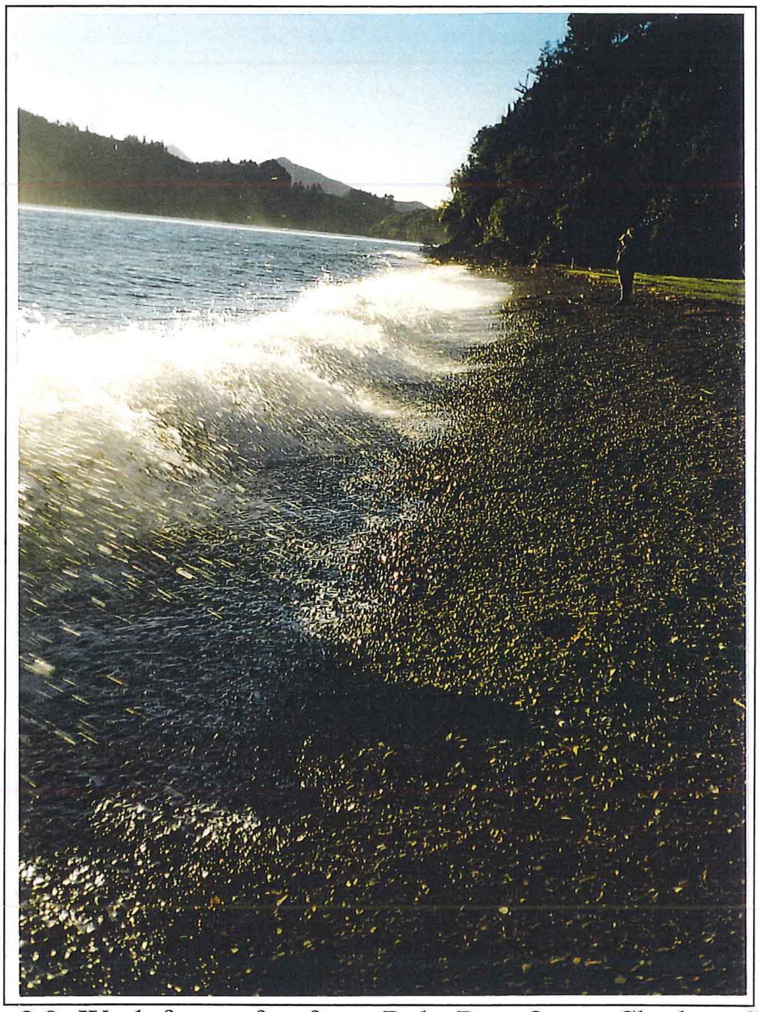


Plate 3.9: Wash from a fast ferry, Bobs Bay, Queen Charlotte Sound.

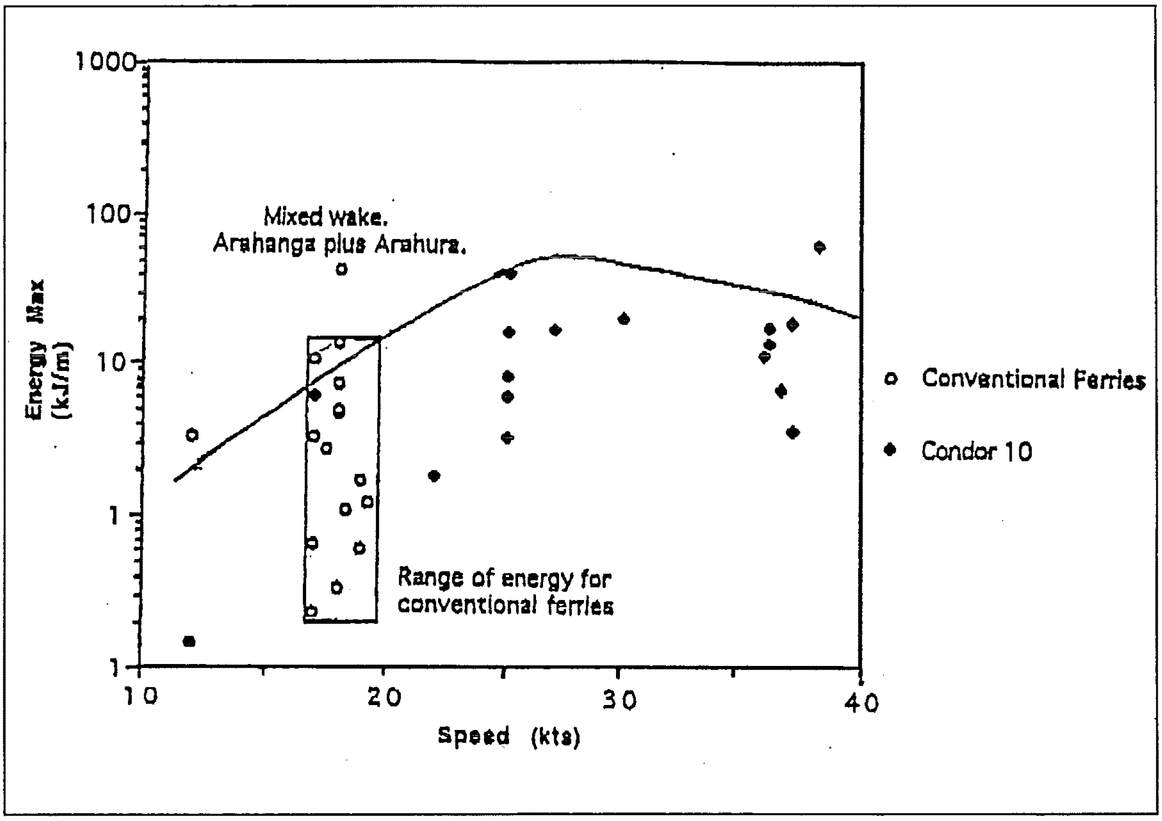


Figure 3.7: Wave energy at the beach of 'Condor 10' and conventional ferries (Kirk, 1995, Figure 2).

Ship service speed throughout the ferry corridor is 38 knots but tides which flow rapidly in the area can significantly increase or decrease these speeds. Ferries operate often at similar times to conventional ferries which travel at 18 knots in the Sounds. Therefore on occasion vehicles must pass each other resulting in a combination of fast and conventional wake, forming yet another wave regime. Single and Kirk (1995), found that combined wake events had a 9% frequency when monitoring wave height and period of fast and conventional ferries in Tory Channel over 21 days of fieldwork.

Single and Kirk (1995), found that measured shoreline changes were generally small and dominantly accretional after and during the first season of fast ferry operation. Evidence of this was shown in their data from a capacitance wire wave gauge and from repeated beach surveys. Results indicated that fast ferry waves had more power than conventional ferry waves so had more energy to transport material. They also found that the steepness of fast ferry waves was low. Waves with lower steepness are associated with accretion and as steepness increases, beach erosion increases. These findings are in keeping with other reports of fast ferry effects on beaches in other areas of the world (Danish maritime Authority, 1996, 1998; Kirkegaard *et al,* 1998).

Kirk and Singles (1995) findings were also in keeping with some of the observed effects reported by Sounds residents since the introduction of the fast ferry. Residents claimed that beaches were becoming steeper (accreting) as boulders were cast onto the foreshore from the surf zone and the shallow inshore seabed (Single and Kirk, 1995). Note that these results relate to the data obtained from the 1995 fast ferry 'Condor 10' which is a different boat to 'Vitesse' that is being used now, but had a similar wave train to the current boat used. Most beaches have maintained their accretional state during summers when fast ferry operate, indicating that the fast ferries are still having similar effects on beaches.

Six possible effects of the fast ferry operation were identified by Kirk and Single in the Planning Tribunal of March 1995.

a) Beaches will become coarser and steeper and will aggregate as they get closer to the ferry sailing line.

b) Beach response to fast ferries will be initially rapid but as adjustment reaches a new equilibrium, beach change will become less pronounced.

c) Wake waves from fast ferries will cause short term fluctuations of a similar order of magnitude as conventional ferries.

d) Removal of hillslope material may lead to short term input into the coastal system (for example at Moioio Island, slip debris has caused accretion to the beach profiles).

e) Siltation in the nearshore and offshore may increase in the short term.

f) Structures in the coastal zone will continue to cause adjustments to adjacent shores and to the structures themselves (this can be seen in the Thompson – Herrick Residence, Ngaionui where the wharf damage has been significant).

These effects have in fact occurred since the introduction of fast ferries.

Dr Single from the Department of Geography, University of Canterbury, has been working as a adviser for Tranz Rail on the response of beaches in the ferry corridor to the fast ferries waves since the introduction of fast ferries in the summer of 1994-1995. His data has revealed some interesting results, often quite contrary to public perception of how the beach is responding to fast ferry wake waves. Initially, 16 profile sites in Tory Channel and Queen Charlotte Sound were monitored. The number of sites was increased to 21 in August 1995. Sites were chosen because they had been noted as being of concern to users and/or reflected some of the different shore types and aspects of the ferry corridor.

Monitoring during the first summer (1994/1995) found that five of the 16 profiles accreted, two sites showed erosion and nine sites had minor changes in volume (less than $\pm 0.3 m^3.m^{-1}$ of beach, two erosional and seven accretional). Between February and August, eight of the 16 sites exhibited erosion, 4 accreted, while the other 4 showed minor accretion. Over winter and spring, nine sites out of 21 exhibited erosion and three sites accreted while nine sites had minor changes. After one week of fast ferry operation in December 1995 eleven of the 21 profiles underwent accretion greater than $\pm 0.3 m^3/m^{-1}$ of beach, while only two profiles underwent erosion. This indicates that fast ferry operations had resulted in building up the beaches rather than eroding them.

Table 3.2 presents data displaying beach volume change since the introduction of fast ferries (compiled from Single 1996, 1999a, Ash 1997). Negative values indicate erosion while positive values indicate accretion of sediment. There was however no base line study of the beach environment directly prior to fast ferry introduction, apart from Newtons thesis in 1977, which was too long before the introduction of fast ferries to assume a baseline state of beaches in 1994. The data in Table 3.2 shows that over the monitored period of fast ferry use of Tory Channel and Queen Charlotte Sound there has been very little beach change. Generally sediment has been moved from the nearshore bed to the foreshore resulting in steepening of the foreshore. The most severe net erosion since the introduction of fast ferries being $-3.398m^3/m^{-1}$ at Bobs Bay. This bay is located close to Picton Harbour and Marina. A high proportion of boat traffic goes past this bay so it if difficult to determine whether in fact this bay is eroding due to the introduction of fast ferries or whether a number of factors are influencing beach change. It is interesting to note that The Danish Maritime Authority, (1996) found that when boats accelerated and decelerated at a slow pace the wakes given off were high. They mentioned that this effect was lessened if the boat decelerated quickly. Close to Bobs Bay, all types of boats are undergoing retardation, which may lead to a larger wake at this site. It should be noted that Bobs bay continued to erode during the winter while the Lynx was not operating.

Table 3.2: Beach change in the ferry corridor since the introduction of fast ferries (Compilied from Single, 1996, 1999a, Ash, 1997).

Profile	Volume change 8/2/95 to 9/2/96 (m^3/m^{-1})	Volume change 9/2/96 to 26/2/97 (m^3/m^{-1})	Volume change 2/8/97 to 5/12/98 (m^3/m^{-1})	Volume change 5/12/98 to 16/12/98 (m^3/m^{-1})	Volume change 16/12/98 to 22/1/99 (m^3/m^{-1})	Net change 5/12/98 to 22/1/99 (m^3/m^{-1})	Net change 8/2/95 to 22/1/99 (m^3/m^{-1})
Bob's Bay	-0.924	-1.776	-1.522	-0.569	0.602	0.033	-3.398
Slip Beach	2.117	-2.721	0.061	-0.777	1.647	0.870	1.659
Te Weka Bay	-0.144	0.666	0.534	0.347	0.030	0.377	0.156
McMillan's Bay	-3.292	1.226	0.450	0.498	0.296	0.794	-2.239
McMillan's Bay 2	0.289	0.392	0.545	-0.287	0.074	-0.213	0.471
Moioio Island	1.620	0.801	-1.058	-0.092	-0.361	-0.453	0.503
Moioio Island 2	1.163	-0.647	2.380	0.847	0.763	1.610	5.155
Kaihinu Bay	0.450	0.487	0.398	-0.539	-0.088	-0.627	0.363
Kaihinu Bay 2	1.090	-0.006	0.291	-0.653	0.058	-0.595	2.542
Te Weuweu Bay	-0.603	0.049	1.289	-0.258	-0.590	-0.848	-1.519
Te Pangu Bay	-0.007	-0.121	0.281	-0.320	0.094	-0.226	-0.127
Te Pangu Bay 2	-0.973	2.325	0.058	0.934	-0.540	0.394	-0.609
Tipi Bay	-0.203	-1.035	0716	-0.635	0.291	-0.344	0.087
Te Awaiti Bay	-0.185	-2.065	-0.647	2.499	-1.301	1.198	-0.977
East of Deep Bay	0.279	-1.905	1.388	-2.156	1.415	-0.741	-0.725
Forest Area LNF	0.349	-3.333	1.067	0.587	-1.234	-0.647	-0.567
Golden Bay	-1.409	0.005	-2.075	0.686	-0.510	0.176	-3.071
Ngaruru Bay	-4.244	1.726	1.605	-0.555	0.883	0.328	-2.101
Wiriwaka Bay	0.900	1.662	1.635	1.622	0.006	1.628	0.576
Power Lines	1.509	0.309	0.129	-0.477	0.514	0.037	0.646
Ngaionui Bay	0.506	-1.822	0.705	-0.396	-0.010	-.0406	-2.750
+ =accretion,	- =erosion						

In keeping with the findings from Single (1995-2000), Parnell (1996) found by using sediment tracer experiments that sediment close to the sailing line was being moved landward immediately following fast ferry reintroduction, but more equal landward and seaward movement was evident after beaches had adjusted. In McMillans Bay, bolder sized material was moved up to 7.6m and other material up to 17.1m. This was the most active site studied by Parnell but represents the capabilities of fast ferry waves to cause sediment movement. Parnell (1996), also found little change in beach profiles after the first two seasons of fast ferry operation. He did note erosion at Moioio Island and Te Weu Weu Bay, the later being due to a seawall construction. The Moioio Island site could be eroding due to fast ferry influence but Parnell is not conclusive on this point. It is important to note that fast ferries do not operate in isolation and conventional ferries and other ships as well as natural storm events also have an effect during study periods.

Bell (2000), was commissioned to write a report by the Marlborough District Council outlining a preliminary engineering geology evaluation of slope instability along the ferry corridor. Bell suggests that the causes of the landsliding in the area include, saturation during natural storm events, wave action at the shoreline under storm conditions, wake action from boat traffic especially in Tory Channel, and in some cases farming or roading activities. Fast ferries are not concluded to have sole responsibility for instigating slope movement, although they appear to be a contributing factor in some areas of continued slope instability.

Bell (2000) identified 95 landslide features in the ferry corridor (Figure 3.8). Table 3.3 summarises the results, showing that the principal failure type is one of shallow landsliding in colluvium derived from *in situ* bedrock weathering and downslope transfer of material. Most landslide features where identified on the south side of Tory Channel due to the bedrock being more highly weathered than on Arapawa Island (Figure 2.2). Much of the failures in Queen Charlotte Sound are on the south facing side and are relatively small and inactive. The north facing landslides are related to stripping of weaker weathered schist and greywacke rock by larger natural waves having longer fetch distances and higher energy levels. There were also five slides located on the North side of The Snout just out of

Picton (Figure 3.8). These slides were actively enlarging and initiation was considered to be caused by wave action.

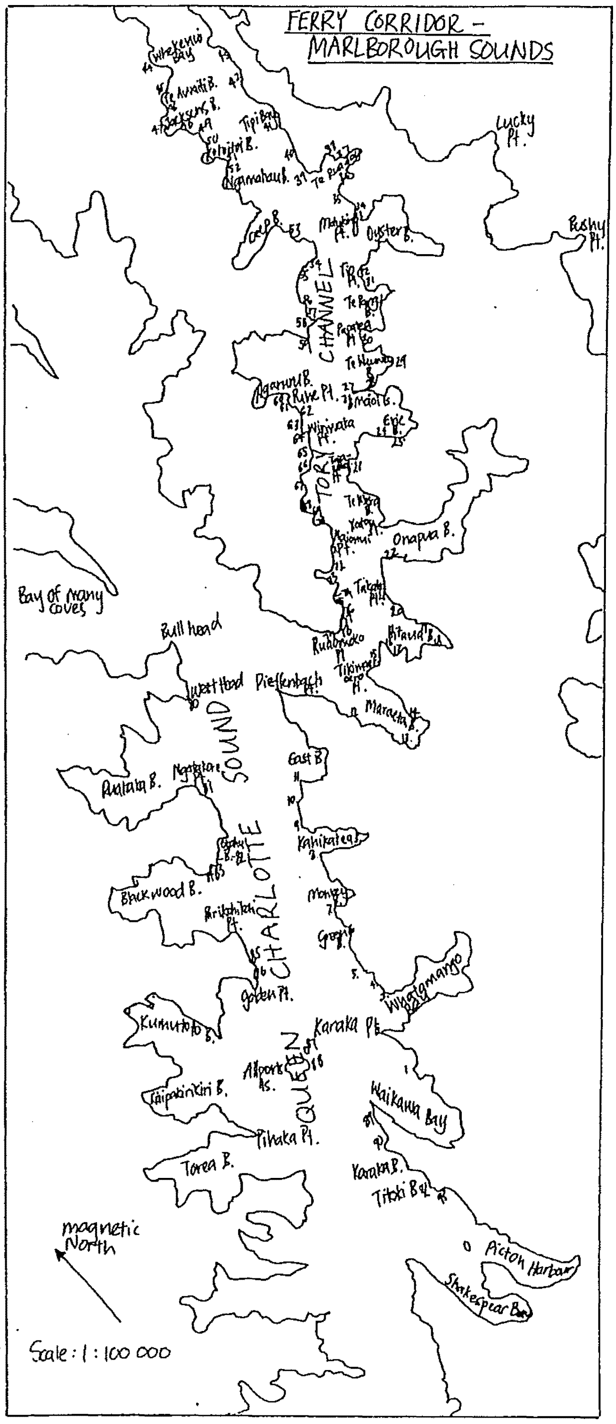


Figure 3.8: Map of the Ferry Corridor in the Marlborough Sounds (Bell, 2000, Appendix 1).

Table 3.3: Landslide failure types as identified by Bell (2000, P.3) in the ferry corridor.

Failure Material	Number Identified	Percentage of total
Strong and/or fractured schist bedrock	14	15%
Weathered *in situ* schist bedrock	11	11%
Weathered schist bedrock and colluvium	11	11%
Schist and/or greywacke-derived colluvium	57	60%
Reactivation of existing landslide deposits	1	1%
Reworked beach deposits	1	1%
Fill from roading activities	1	1%

Considerable effects on the coastal structures in Tory Channel are claimed but the causes are uncertain. Many of the structures are ill designed and in urgent need of repair, many have been corroding or decaying for some time. It is difficult to estimate whether the damage is in fact fast ferry related. These structures also affect sediment transport in the coastal zone, often causing erosion due to how they interact with waves. Common forms of erosion adjacent to structures include undercutting of the toe, out flanking causing scour at the ends and leading to attack from the rear.

3.6.2 Local perception of the effects of fast ferries on the coastal zone

The concept of equifinality is an issue relevant to many areas of the Sounds. Long Beach, situated in the Grove Arm (Figure 2.2) has gradually been eroding over the last few years. There have been no beach profiles surveyed in this area, although evidence of beach retreat and personal communication indicates some beach change has taken place. The council has some monitoring sites at this beach now. Mr Dew, a bach owner in the bay claims that incoming ferry waves have a significant effect in the bay and are transporting beach sediment offshore (David Dew *pers com*, 19.01.00). Wakes from outgoing fast ferries barely affect the area.

There is a rock wall situated at the eastern end of the bay in order to protect the owners house situated on top of a small cliff. Rock work prevents undercutting of the cliff and needs replacement every year. This costs the owner $3000 a year but is unavoidable as his assets need protection (Tranz Rail and Topcat are paying for some of the damages through an out of court settlement (Marlborough Express, 06.09.2000, P.1)).

The north west wind in the area forms a wave regime that deposits material on the beach forming accretion of fine sands. Over the last two years however, there have been few north west winds hence sand is being removed perhaps by ferry waves and not being naturally replaced by the favourable wind regime. The owner although situated just a bay around from Shakespeare Bay (Figure 2.2), felt that the ships using the new port were not contributing to the sediment removal because only two ships came in a week and both moved very slowly (David Dew, *pers comm*, 19/01/00). There are several different possible causes for the coastal change at Long Beach, it is difficult to ascertain the actual cause of change.

The perception people have of the ferry wake wave damage is often different to reality. This is clearly seen at Ngaionui Bay (Figure 2.2). Ngaionui has been owned by the Thomas family since 1979 (after the introduction of the slow ferries). It is still in the family and owned by their daughter and son in law (the Herricks). Ngaionui is situated close to the ferry sailing line and is subject to both incoming and outgoing ferry wakes but especially to the wake of incoming vessels. Waves are especially bad if in combination with a south east wind and spring high tide. In these environmental conditions the waves from fast ferries can reach up to the steps at the front of the house (Plate 3.10). Longer period waves like those produced by the fast ferries have a higher runup (Croad, 1995), and have posed a threat to assets at the Ngaionui property.

Plate 3.10: The higher run up of fast ferry waves reach inside the front gate of the Ngaianui property.

Stones are thrown up and the beach front is increasingly steepening. These stones are changing the use of the beach. This beach was reported to be steepening by Newton in 1977. Once grassed areas have been replaced with stone and the boat shed cannot be used as the rails are covered with ferry strewn rocks. Plates 3.11 and 3.12 show the changes to the steepness of the beach and how the boat rails have become buried by stones. The jetty has been severely damaged and is unsafe to walk on. The design of the jetty forms an 'L' shape with the seaward end being parallel to the sailing line of the ship. The seaward end of the jetty was built eight years ago and the rest of the jetty is 50 years old (as old as the house). Waves from the fast ferry can completely immerse the jetty (Plate 3.13). The owner of the jetty is quite prepared to replace old boards where the nails have rusted through but plans to take the ferry companies to court over the destruction of the new section of the jetty.

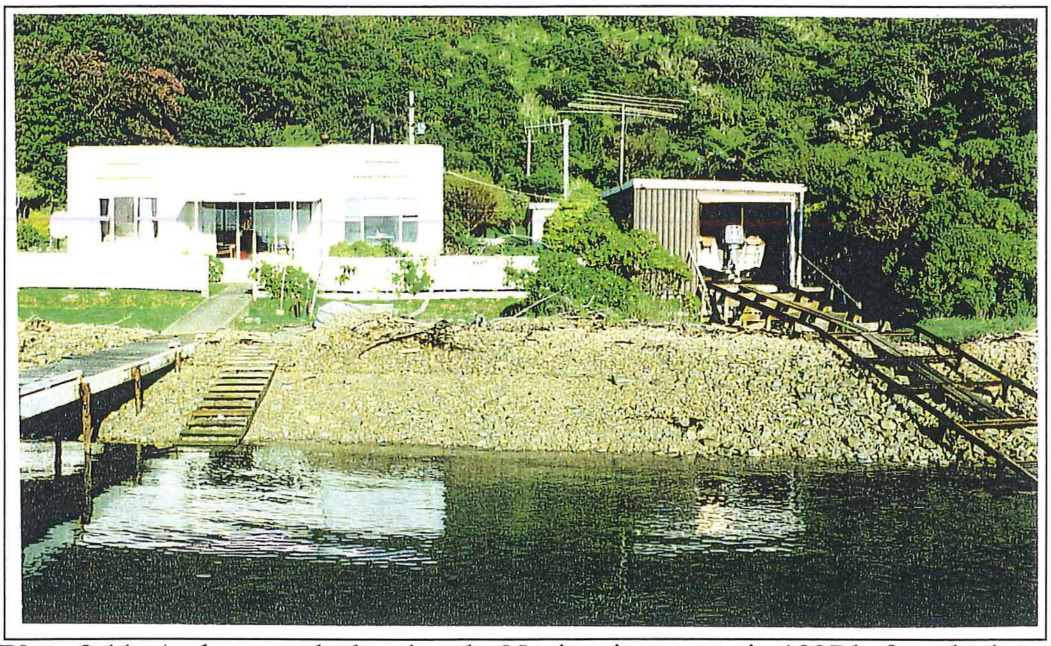


Plate 3.11: A photograph showing the Ngaianui property in 1987 before the introduction of fast ferries. Note the boat ramp lies above the beach.

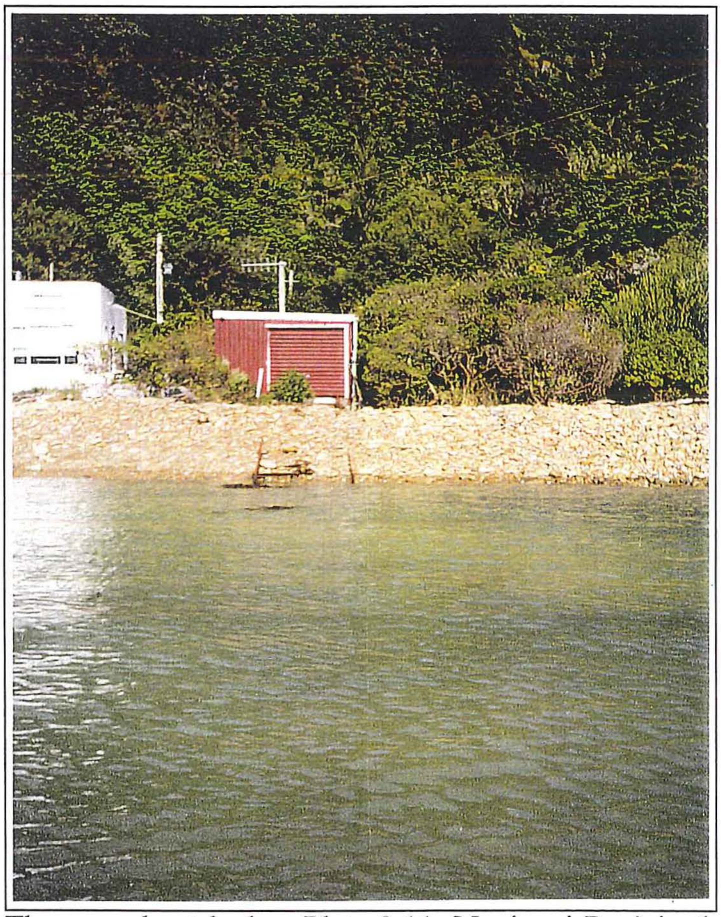


Plate 3.12: The same boatshed as Plate 3.11 (Ngaianui Bay) in the summer of 1996 with the boat ramp covered with large cobbles that have been moved onto the beach.

Plate 3.13: Fast ferry waves emmersing the jetty (Ngaianui Bay, Tory Channel).

Mr Herrick estimates that the erosion of the coastal zone is approximately 1m per year. Survey results form Singles work show that this bay has eroded 2.7 metres since 1995. Mr Herrick admits that there has always been erosion in the bay but it has accelerated since the introduction of fast ferries. The front of the property is bordered by a wooden fence and some ice plant. The ice plant however is getting undercut due to weak material from a recent slip comprising the beach front. Plates 3.14 and 3.15 show the shoreline prior to the fast ferry introduction. Newton noted retreat rates of 10.44 cubic metres per year from scour pins by the grassed area in front of the house (shown in Plate 3.14) suggesting that the bay was eroding in the 1970's. It is possible that more fill had been placed on the beach between 1977 and 1984 (as shown in the foreground of Plate 3.15, where the ground is depressed through lack of compaction). Plate 3.16 is the same view in 2000 and shows the marked erosion of the backshore due to the erosion of landslide material. It is important to note that the material making up this beach and adjacent land was formed from past landslides. Plate 3.17 shows the material from an old landslide (Photograph taken in 1988). Landslide material can be identified due to the absence of developed soil layers. The landslide material was unconsolidated and highly erodable and not the usual beach forming material. A further landslide occurred in November 1994 just prior to the introduction of 'Condor 10'. Material from the slip was bulldozed onto the beach seaward of the white fence in

Plates 3.14 and 3.15. The increased rate of erosion over the time of fast ferry introduction was likely due to the ease of removing this unconsolidated sediment, which does not usually make up the beach material at Ngaianui and is incompetent to do so.

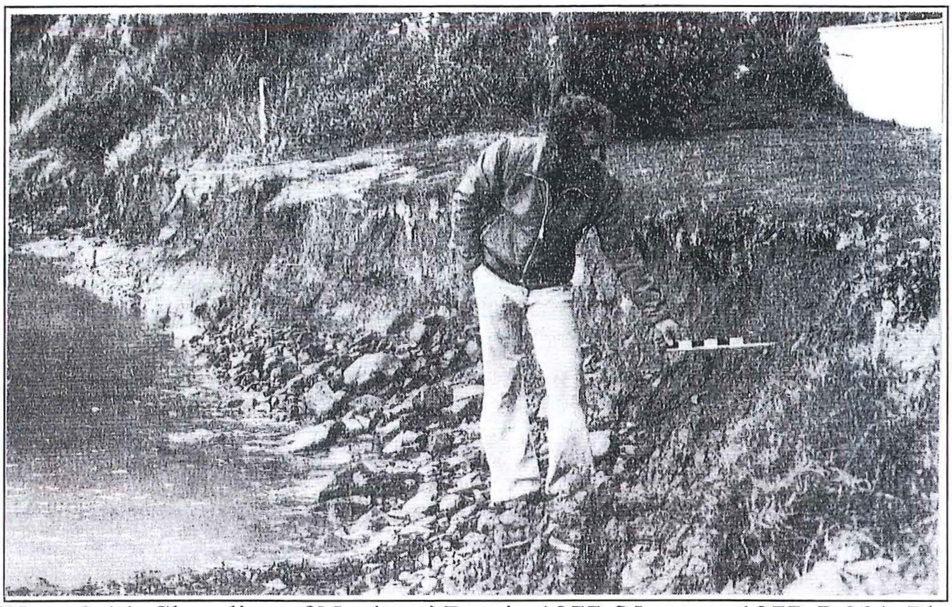


Plate 3.14: Shoreline of Ngaianui Bay in 1977 (Newton, 1977, P.201, Plate 28). Notice the amount of land between the white fence in the top right hand corner of the picture.

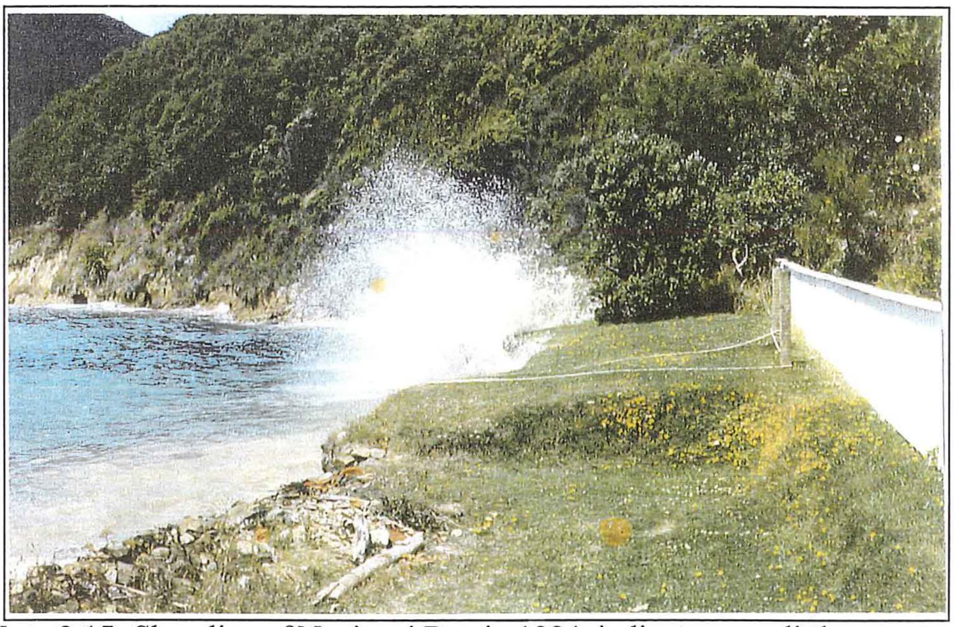


Plate 3.15: Shoreline of Ngaianui Bay in 1984 indicates very little retreat since 1977 (Plate 3.14).

Plate 3.16: Shoreline of Ngaianui Bay in 2000, The shoreline has retreated substantially since 1984.

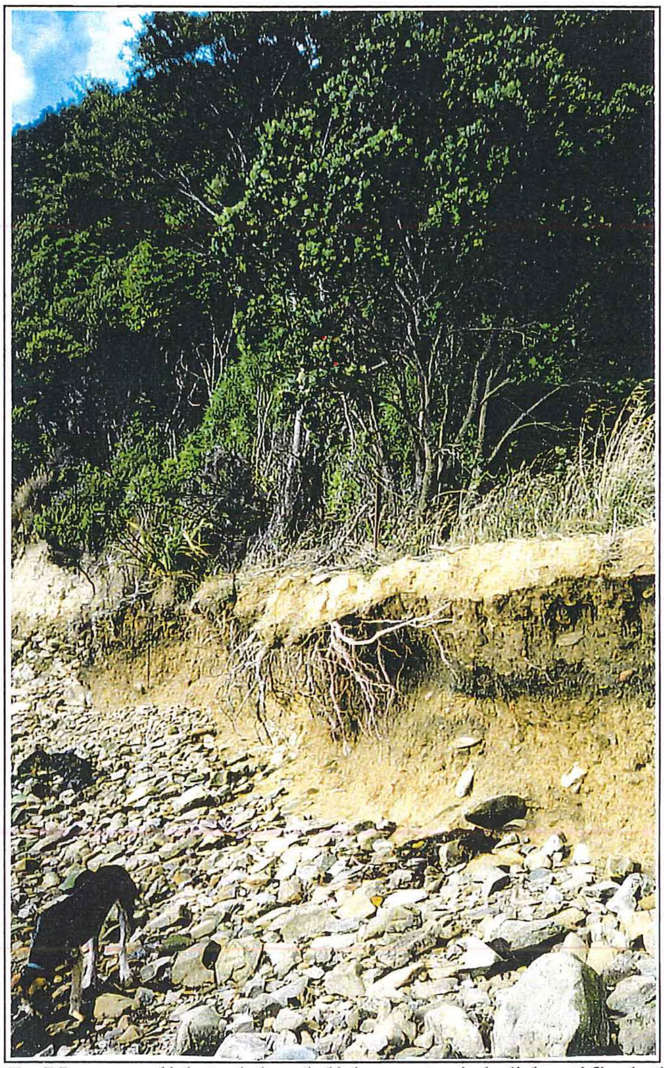


Plate 3.17: Unconsolidated landslide material (identified through lack of established soil layers) forming the shore at Ngaianui Bay.

There is a change in the use of the area. Mr Herrick must untie his boat from the jetty every time a ferry goes past, that is approximately 14 times a day for both conventional and fast ferry sailing's. This is due to the boat ramp being covered by stones and out of use. In the past the Herricks put the boat in the boat shed when it was not being used. The Sounds was once a relaxing break away from his busy lifestyle as a dairy farmer, however now he constantly looks at his watch to see how far away the next boat is (Ashley Herrick, *pers comm*, 15/1/00).

3.7 Management Implications

The Marlborough District Council is currently reviewing different management strategies for the fast ferries. Public concern about the fast ferries wash in the Sounds is prevalent and councillors are under pressure to make progress with management decisions. Over the last year and a half, debates have come to fruition over the ferries. Major concerns from the public include beach erosion, safety, and to a less effect negative impacts on tourism. The council has been monitoring various aspects of the fast ferry wake and its effects. Issues that the council have been monitoring, have in some instances been different to public concerns, this will be addressed later.

The Council have commissioned studies by an Australian risk assessment group who have produced some statistics as to risk to life, and injury as well as probability of a boat over turning. It was estimated that the fast ferry would be expected to overturn a small craft once a year and a death every four or five years was predicted. This study's findings are flawed due to the lack of reported accidents with ferry waves and the lack of known use of the area (for example, boat numbers and bathers using the coastal inland area). Safety incidents are under-reported and information about them is inconsistent (Marlborough Express, 04.02.2000, P.1). To date there has been no evidence of any serious safety incident in the Sounds involving the fast ferries although the bylaw's aim is to address the safety issue (Marlborough Express, 04.07.2000, P.2).

For swimmers and holiday makers, the wash on calm days can come as a surprise – this is when the wash from fast ferries can be dangerous (Johnson, 1969). Where ship waves are present and wind waves are relatively small (as in the Marlborough Sounds) people can be caught off guard when large waves from passing vessels hit the shore (Johnson, 1969). This could be over-come by informing the public about possible wave problems by indicating the ferry route on charts, distributing brochures (especially in hotels and tourist centres and by erecting signboards in public places (for example, beside boat ramps or coastal areas that are particularly exposed to the fast ferry wake).

A social impact report was undertaken by Corydon Consultants under the commission of the Marlborough District Council. This assessment found that the rate of reported safety issues had increased considerably since December 1999 (30 incidents were reported between1995 and 1999, nine of which were fast ferry related, while 36 incidents were reported from December 1999 to April 2000) (The Press, 01.09.2000, P.6). The fast ferry service has been operating for over five years yet when they were first introduced there were few complaints of safety. This suggests that there is some other influence resulting in the increased safety incidents being reported in the Sounds. This may be due to the issue becoming more topical and publicised and educating people as to how to report safety incidents. In the same report, it was found that of the 180 residents surveyed, 109 reported that they had experienced a safety-related incident due to fast ferries. This document focused on a small group of people (mainly Sounds residents rather than the wider community of Marlborough) and relied heavily on anecdotal evidence. Outcomes from this study must be seen in light of these flaws.

It is in the Councils best interests that public acceptability of wakes must be reached. The Danish formula (which Croad (2000) has based most of his suggestions to Council on) says a wave height of 0.3-0.6m at a depth of 2-3m and 1-2km from the sailing route is acceptable. Will the public be satisfied with this level of wake? The wave height can be significantly bigger at the coast in depths shallower than three meters due to shoaling. The wave period must also be addressed, as the long period wave produced by the fast ferries can pull young children out to sea. It is important that when ships pass through critical speed, it does not coincide with sensitive coastal areas or areas of high recreational use.

To address the safety issue, the Council proposed using the Danish 'rule' for deep water, in order to control the wave height produced by fast ferries. This formula was proposed and put through the submission process which heightened a number of weaknesses to the proposed equation. Problems include the simplicity of the formula. Hull configuration, slower or faster speed and distance of sailing line to shore, tidal stage, wind speed and direction will influence wave height and all these variables need to be considered in order to reduce wave height at the shore. However the ships speed and water depth are the only variables that are changeable in the equation. If this wave height formula is adopted it will be over to the operators to apply the formula (Marlborough Express, 13.03.2000, P.1).

The Council found too many problems with the formula and realised it would not be accurate in the Marlborough Sounds environment. The Danish organisation offered to change the formula to suit the Sounds conditions but this option was considered to be too costly. Instead of following with the Danish formula, the Council decided to impose speed restrictions based on the work of Croad (2000) who uses a revised version of the Danish formula. The speed restriction is 18 knots for all vessels in the Sounds. This will obviously make the service a slow fast ferry and sailing times would increase dramatically (approximately 30 minutes longer for the 115 minute crossings). This proposition is not cost effective for the ferry service and it would inevitably terminate operation if this enforcement was long term. This speed limit was proposed on the assumption that there is relatively little difference between a large fast ferry and a conventional ship at roughly the same speed, although no testing of the 18 knot speed and its relationship with wave height has been undertaken by the Council.

Tranz Rail has other options rather than terminating the fast ferry service altogether. It purchased some land in Clifford Bay in the 1970's and that land can be used to make a new ferry terminal. This would cut out two major hills for the trains to climb on their trip south (the climb out of Picton and the Dashwood climb) and would cut time off the ferry crossing between the two islands. These benefits would make this option viable both financially with less fuel being used, current engines could be used to pull double the weight without increasing locomotive power, due to less steep climbs, and in speed of service as trips would take less than 24 hours from Auckland to Dunedin. The building of the Clifford Bay terminal will have a construction period of three years so there may be a lag time before the ferries can operate there (Rails, 2000).

In contrast, 'Top Cat' would find that running a service would no longer be viable and this will bring loss of employment and a decrease in competition for fast ferry services, possibly making ticket pricing from Clifford Bay to Wellington too expensive for some users. Changing the ferry terminal from Picton to Clifford Bay could have dire consequences on the townships of Blenheim and Picton. Ideas have been surfacing that these areas will be looked apon as destinations rather than somewhere to pass through as traffic from the ferries move on to the larger cities south and that business will remain the same or increase due to that fact. This is disputable as many of the small businesses rely on the passing ferry traffic for an income. The council must contemplate all angles of the problem when inforcing this bylaw as many will be affected due to their decision.

The council has been monitoring the beaches in the ferry corridor since 1995 and are currently monitoring areas along Grove Arm. This data is necessary for understanding of what is happening in the coastal system. Had a monitoring program been in place prior to the introduction of fast ferries, it would have identified the effects of fast ferries on the coastal system. It is important that beach monitoring continues in case future water use changes have impacts on beaches, so that beach change can be identified rapidly. Monitoring also fulfils a requirement of the Resource Management Act (1991) to monitor the environment (Parnell, 1996).

The effects on tourism have not been studied. The public concern that the fast ferries are impacting adversely on tourism stems from the idea that many locals want the Marlborough Sounds area to be depicted as untouched and natural. The public view is that with the presence of fast ferries in the Sounds, this natural image is tarnished. However, the fast ferries bring a lot of the tourists to the region and without their services tourism in the area could drop.

There has been the suggestion that ferries should travel at times that do not coincide with high tides, or separate sailing times so as one ferry travels every hour. At present, two fast ferries and the 'Aratere' - the three worst wake producers leave Picton within minutes of each other therefore it is not unusual for a number of ships to be in the Ferry Corridor at one time. If all three vessels coincide with high tide the effect on the beach can be quite noticeable. Having staggered sailing times would decrease the incidents of two vehicles passing in the Sounds (which leads to an increase in wave height) and would leave some recovery time for coastal fauna but would be difficult for users of the ferry corridor. Boats need to be taken off jetties at every sailing. If this was every hour it would severely disturb people's holidays.

Vessels must sail in the shipping lane, which is outlined in the Marlborough Sounds resource management plan. Outside of the shipping lane, vessels must sail at less than 18 knots (Alex van Wingaarden *pers comm.* 15/02/2000). Sailing distance from shore varies from point to point. At no point during the journey through the inner Sounds is the ferry greater than one kilometre from the shore. Vessels must sound the horn on a blind corner (for example Clay Point). No passing areas are present in areas with sharp bends (for example, Deffinbach Point, Heaffy Point, Clay Point, Arrowsmith Point and Tory Channel eastern entrance) for navigational safety reasons.

There has been concern from small commercial and recreational vessels of the danger of collision due to the high speed of fast ferries approaching blind corners and the congestion in narrow channels caused by large commercial vessels overtaking each other (Tory Channel Navigational Safety Group, 1999). The Tory Channel Navigational Safety Group, (1999) suggested that this may be overcome if the estimated time of arrival at each point are broadcast on VHF and whistle signals sounded. They also suggested that fast ferries drop speed by five knots during major course alterations and restrict passing in narrow areas. Various regulations are enforced by resource officers through a complaint basis. If a complaint can be proven, boat companies can incur fines. However these fines are small and never exceed $500.

Changing the boat hull is a proposition put forward by Steve Schmidt owner of Naiad Inflatables Ltd, recognised internationally for the design and construction of rigid hull inflatables less than 14 metres in length (interviewed by the Marlborough Express, 17.4.00, P.2). Operators of fast ferries, utilising the Marlborough Sounds should put onus on designers and manufacturers of these vessels to come up with hulls producing less wash. Designers and manufacturers will not design for low wash unless they know it's desirable and will give them a commercial advantage. Ferry operators should approach those they lease or buy their vessels from and insist they find ways of designing low-wash fast ferries suitable for both open water, such as Cook Strait and enclosed waters, such as Tory Channel and Queen Charlotte Sound. The pattern among fast ferry operators has been to use the most fuel efficient and revenue gaining system of getting people across Cook Strait, now they must look at safety and environmental issues (Marlborough Express, 17.4.00, P.2). A possible option is to instigate legislation giving the shipping agencies incentives to design low wash ferries.

Management implications are heightened by the fact that few people know who is responsible for the policing and restriction of fast ferry activities. The government has put sole responsibility on the Council. Mrs Hobbs (Minister for the Environment) when asked if the government was willing to support the Marlborough District Council in monitoring programs was reported to have said that the Marlborough District Council had "all the legislative powers to deal with the problem of the fast ferries itself" (Marlborough Express, 18.02.2000, P.1). The government although appalled at the effect of the fast ferries, are not prepared to free more money to the Council or DoC for monitoring. However the Council is less likely to act unless it has the support of government (Marlborough Express, 18.02.2000, P.1).

The Department of Conservation which administers the foreshore is doing nothing about protecting the foreshore reserve from alleged destruction from fast ferries. Therefore owners end up protecting their own land plus that of DoCs land. DoC see the issue as being caused by the fast ferries and do not feel it appropriate for the department to clean up the ferries 'mess'. Approximately 10 resource consents are processed each week, some for sea walls and other protective structures to stop the ferry wash effects. You would presume that DoC would be against the construction of such structures as they are concerned with the conservation of areas. Modifying an area as dynamic as a beach will end in an array of problems, especially if the structure is poorly designed or built. Many of the structures in the Sounds are not suitable for the conditions and do not satisfy the Resource Management Act (1991) but are still given non-notified consent. This is not a way of conserving the aesthetics or natural processes of an area. Instead building of structures too close to the coast, or on unstable land should be addressed.

Recently there have been suggestions that property owners in the ferry corridor are planning to sue the Fast Ferry companies for damage done by ferry wash through a 'class action suit' (Marlborough Express, 03.08.2000, P.1). This would be a multi-million dollar court case and may involve the hearing of every incident against the ferries depending on how the judge wants the trial heard. There will be difficulties in hearing all the cases together rather than separating each case during the hearing as there are few commonalities of effects. Different sites have different environmental conditions (for example, length to the sailing line, different beach types, different alignment to oncoming natural and introduced waves). The priority of the case was to restore peoples lifestyles and the environment of the Sounds. Grant Cameron from Grant Cameron and Associates, is planning the class action suit and is suing under the Tort of Nuisance, which addresses the situation where if someone is to cause damage, they are liable to the damage of that property (Grant Cameron *pers com*, 05.09.2000). Nuisance can also be addressed when use and enjoyment of an area is affected.

The allegations against fast ferries must be proven which will be difficult for some land owners as hard evidence of for example, beach erosion for example would be crucial but does not exist. In a coastal environment the wear and tear on structures is severe and it would be difficult to prove that the cause was in fact due to the wake given off from fast ferries. Landowners could not sue on areas in the Coastal Marine Area as it is Crown land, therefore DoC may be invoved in some cases. Points raised on beach erosion are not likely to be addressed (Marlborough Express, 3.8.2000, P.1). However Grant Cameron (*pers comm*, 5.9.00) suggests that if this erosion is undercutting their land, structure or property, there will be a case to be heard. The class action suit will be against the Lynx and the Top Cat and does not include past fast ferry companies who may have added to the damage, or other ships and ferries that use Tory Channel regularly.

The Marlborough District Council may also get sued because they allowed for the nuisance to persist. If the speed bylaw proposed by the council comes to fruition, the problem of safety and nuisence to use and enjoyment of the area may be solved. Many people percieve that the bylaw will fix their problems but this class action suit will ensure that damage will stop as it will form an injunction which will over ride the bylaw and prevent the ferries from operating at all. The class action works on the premise that the fast ferries are a lawful activity but the manner in which they are operating is unlawful (Grant Cameron *pers comm*, 05.09.2000).

3.8 Summary

The waves generated by fast ferries are of a type that rarely occurs naturally in the Inner Marlborough Sounds. Due to the higher energy waves produced by the fast ferries, beach change will result – not necessarily for the better or worse but none the less, change will occur. Experts have rejected the perception of locals that beaches are eroding due to fast ferries and have in fact found most are accreting. Beaches change rapidly to their environment especially to changes in wave type and direction. Beaches are always working towards an equilibrium and this equilibrium adjusts as the environment changes. Beaches changed with the introduction of fast ferries due to a change in wave environment but have now reached a new equilibrium and are quite stable. Change will not be ongoing therefore the water use of fast ferries on the coastal zone is sustainable in terms of the Resource Management Act (1991).

It is concluded that environmentally fast ferries are having little effect on the coastal geomorphology, flora and fauna, or culturally significant sites. The fast ferries have had a positive influence on Marlborough's economy and tourism in the Marlborough Region.

The following quote from Soucie, (1973, P.56, cited in Komar, 1998, P.5) is applicable to the use of the coast in the Marlborough Sounds.

> 'The real conflict of the beach is not between sea and shore, for theirs is only a lover's quarrel, but between man and nature. On the beach, nature has achieved a dynamic equilibrium that is alien to man and his static sense of equilibrium. Once a

> line has been established, whether it be a shoreline or a property line, man unreasonably expects it to stay put'.

In the Marlborough Sounds the shoreline has been influenced by a number of different artificial and natural waves. The shoreline over time has changed from these influences. Shoreline change is a concept that Sounds residents and users must come to terms with rather than try to overcome through using structures or trying to change the number or type of artificial waves influencing the coast. Humans perceive a change in the land sea interface as an interference with their use of the coast, and fail to recognise that the measures utilised to stop coastal change are futile, often leading to greater coastal change through disruption of the equilibrium and a decrease in the aesthetic value of the coast.

People who live alongside heavily trafficked waterways, or roadways or railway lines, or airports have consciously chosen to do so. Residents of the Ferry Corridor are no exception. The use of the Corridor is getting heavier with the introduction of fast ferries, but it has always been a major shipping route. People's use of the Ferry Corridor has changed as the route has become more intensely utilised.

Public safety is of primary concern, this leads to a conflict in uses of the Ferry Corridor, namely between private boat users and local inhabitants and commercial crafts. This concern has stemmed from the Council's risk assessment that suggested, the fast ferry wake could cause injury and even loss of life. To date there has been no deaths or serious injuries in connection with fast ferry waves but there have been reports of minor injury. Efforts are continually evolving to avoid and mitigate these conflicts but progress will not move forward unless both parties make considerations for each other. Social, economic and environmental aspects must be considered before making decisions as to whether the fast ferries should continue operation as a fast service between the Islands.

The introduction of fast ferries has changed the landscape of the Marlborough Sounds through the increase of boat traffic through Tory Channel and Queen Charlotte Sound. This change has been bought about through the technological advancement of the resource of boat transportation. The introduction of fast ferries has economic and social advantages to the Marlborough region and has been found to have little environmental effect. Fast ferries as a resource has not been realised by some residents of the Sounds, due to its conflict with other uses of the Sounds, such as recreation. The future of fast ferries as a water resource in the Sounds is unclear. It has little support as a use regionally, reflecting the Councils actions to slow the ferries. Nationally it is an important and heavily utilised resource, that may not be realised until it is gone.

The following chapter discusses the land use of forestry and its role in changing the landscape of the Marlborough Sounds. This use is also controversial and is having a perceived effect on the coastal zone and landscape value in the Sounds.

CHAPTER FOUR

Forestry as a land use in the Marlborough Sounds

Different stages of forestry in Tory Channel, Marlborough Sounds.

'The whole scene forms a labyrinth on an immense scale, in which, you may lose your way among tortuous paths two or three miles broad and in between hedges composed of mountains from 2000-3000 ft in height, clothed to the summits with the most luxuriant and majestic timber'

John Wakefield, 1839.

4.1 Preamble

At first glance to a casual observer, forestry and ferries in the Marlborough Sounds would seem to have little to do with each other. However, both of these phenomena are utilising resources in the Sounds and are causing coastal change. This is an important issue because the coast is the most heavily used area in the Sounds, leading to some forestry activities conflicting with other uses of this space.

The Marlborough Sounds is an environmentally sensitive area and any activity which may be environmentally degrading is carefully scrutinised – forestry is no exception. The principal uses of resources in the Marlborough Sounds are farming, forestry, reserves, tourism and recreation, fishing, shipping and residential development. Forestry may compete with other uses for space but the major potential impacts are from forest management practices, especially in the coastal zone where the most uses are concentrated (Field, 1976). Potential sources of conflict between uses include burning, roading, logging operations and visual impact.

Commercial Forestry is defined by the Resource Management Act (1991) as follows:

> 'a land based activity having as its primary purpose, the growing of trees for commercial wood production. This includes the planting and replanting of the trees'
>
> (Amendments of the Commercial Forestry Consent Order, 1999).

This process of planting and replanting trees is occurring in the Marlborough Sounds and is coming to a head as large areas of trees are maturing simultaneously and are currently being felled and in some cases replanted. At this crucial time of the forestry cycle, it is important to monitor and gauge the effects of the processes on the coastal zone because of the potential effects of forestry to the nearshore and coast in the Marlborough Sounds.

This chapter aims to look at the effects of forestry both generally and on the coastal zone. The topic will be placed in context by giving a history of forestry both in New Zealand and the Marlborough Sounds', as this is both a local and national issue, and discussing the appropriateness of this landuse in the Sounds. Section 4.6 discusses the general effects of exotic forestry production in the Marlborough Sounds and is followed by an experiment relating to the effects of forestry on the coastal zone. Finally, catchment management is discussed in the broader context and at the local scale.

4.2 Introduction of exotic forestry in New Zealand

Clearance of indigenous forest after Europeans purchased land from Maori continued until the early 1900's. Figure 4.1 shows approximately 50% of the land had been cleared by 1910. Concern for the diminishing area of forest was expressed by the Commissioner of Crown Lands who advocated extensive planting of exotics (Field, 1976). This led to an inventory of the forest estate in New Zealand in the 1920's in order to start planting exotic tree species to resolve the timber deficiency and to reserve some of the native forests from economic exploitation. Pine plantations were seen to be a complement to, rather than a substitute for, indigenous forestry. In 1960 the Forest Service reviewed the national wood supply and demand for timber and found a temporary surplus from the first planting boom but a future deficit at the end of the century. As a result, a second planting boom began in the 1960's. At this time plantations were viewed as a substitute to indigenous forests and they decreased the pressure on native forest areas (Memon and Wilson, 1993 cited in Hedén and Borgström, 1999). In the 1960's the sawn timber cut from pine plantations equalled that from the natural forests. By 1978 it was seven times greater, by 1984 fourteen times greater and by 1993, 36 times greater (Purey-Cust and Hammond 1995, cited in Hedén and Borgström, 1999).

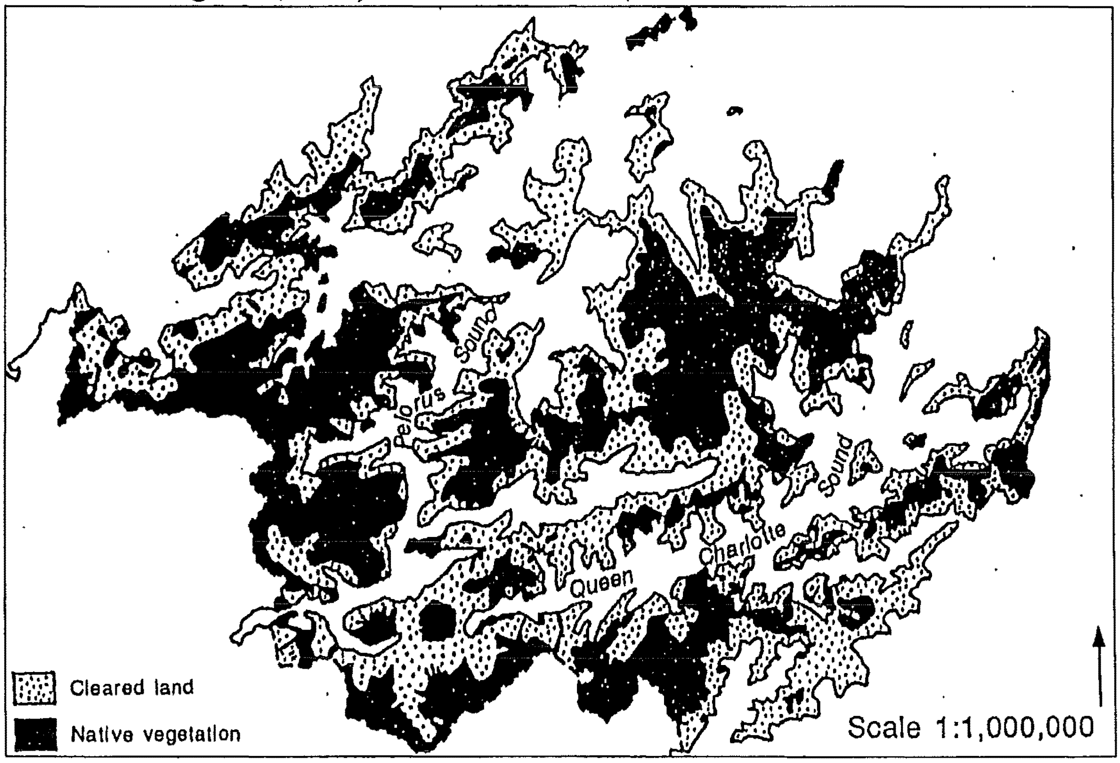


Figure 4.1: Amount of land cleared in the Sounds by 1910 (Bowie, 1963 cited in Lauder, 1987, P.50)).

Gradually over time forestry replaced many areas that had been agricultural land. The motivation for some farmers to change their land use came relatively late. Many farmers perceived that forestry was not a respectable land use – "It was an ovine/bovine world and real men dagged sheep and erected fences" (Hocking, 1994). However, today, private plantations on formerly agricultural land has led to a shift from the domination of large corporates in the forest estate to individuals, groups of small investors and farmers (McGregor, 1997). At present 70 – 100 000 ha of agricultural land are being removed from agricultural production by forestry plantation per year (Maclaren, 1996).

Today, forestry is a major export earner for New Zealand and this is going to rise. In 10 years time forestry will be the number one export earner as the trees from the 1970's and 1980's planting boom will be mature. New Zealand has a total land area of 27,053,400 hectares, of that 23.7% is under natural forest cover and 5.1% is in planted production forest (Ministry of Forestry, 1995, cited in Rogers, 1996). New Zealand is in a good position to substitute world wood supplies as many traditional wood supplying countries such as Asia and the Pacific North West are becoming constrained by decreasing yield and conservation pressures (Ministry of Forestry, 1994).

4.3 History of forestry in the Marlborough Sounds

Before land clearance to most areas of the Marlborough Sounds in the 1800's the forest was made up of Rimu (Dacrydium cupressinum) the most plentiful tree on the valley floor, mixed with Kahikatea (Podocarpus dacradioides), Totara (P. totara), and Miro (P. ferrungineus) plus a scattering of Tawa and very large Beech trees. Kahikateas were found to be up to 9 ft in diameter and hence the milling potential of the area was very large (Paton, 1982). Table 4.1 shows the results from Sidney Weetmans (1894) survey of trees in part of the Rai block that covered 118 acres (cited in Paton, 1982, P.11). Only four species were measured as beech was not considered worth milling (Paton, 1982).

Table 4.1: Total number and size of trees in a 118 acre site in the Rai block in 1894 (Data from Weetman, 1894 cited in Paton, 1982, P.11).

	Number of trees	**Superficial feet (total)**	**Average tree size (square foot)**
Rimu	1,023	1,030,600	1,007
Matai	654	312,553	478
Kahikatea	821	759,346	925
Totora	85	142,896	1,682
Total:	2,583	2,245,395	

Forest clearance commenced as early as the 1830's, but was in full swing in the Havelock area from the 1860's. Slowly the forest was felled and the trunks shot down the steep slopes (sometimes by flying fox), dragged into a tramway by bullock power (and later steam locomotive) and hauled to mill sites nearest flat land (Plate 4.1). Timber was soon to be shipped to Christchurch, Wellington or Nelson and sometimes as far away as Sydney. Despite urgent demand for houses and buildings for a flood of new settlers, some areas of forest remained untouched mostly because of their inaccessibility and the difficulties of logging high mountain slopes (Paton, 1982). Table 4.2 shows the amount of timber taken in the Pelorus area by 1928. As well as the mills shown in Table 4.2, several smaller mills were in operation, raising estimates of total timber taken to 400 million feet (122 million metres).

Plate 4.1: Bullock team hauling logs in the Sounds (A. Turnbull Library – Northwood Collection, cited in Ponder, 1986, P.102).

Table 4.2: Approximate amount of timber taken in the Pelorus and surrounding areas up to 1928 (William Brownlee cited in Ponder, 1986, P.153).

Company	**Year**	**Amount of timber removed (million ft)**	**Area of felling**
Brownlee and Coy	1864-1915	189	Mahakipawa, Kaituna, Kaiumu Bay
Dive and Gaby	1864-71	15	Mahakipawa
W. E. Dive	1872-78	12	Hood's Bay
A. Brown	1872-76	8	Mahakipawa
Duncan Bros	1870-74	8	Tennyson Inlet
Duncan Bros	1874-85	16	Kenepuru
Wells and Coy	1866-71	10	Havelock
Others	1870-80	10	Nydia, Manaroa
J. Hornby	1880-85	10	Kaituna
W. Farnell	1865-75	4	Kaituna
Marlborough Timber Coy	1907-19	40	Nydia
Rimu Bay Coy	1925-28	3	Nydia
TOTAL of above		325 million ft	

The end of the gold rush saw an increase in unemployment in the area. Men were eager to pick up work. In those days mills needed plenty of labour to manhandle cut timber into stacks, cut and fill roads for tramways, and do benching and docking jobs in the mill.

A lot of the wood went to waste, as areas where big trees were easily accessible were not properly logged. Good timber was left to fall or be burned by farmers who would later occupy the land, anxious to clear the land and sow grass for sheep. Nearly two-thirds of the natural forest cover in the Marlborough Sounds was cleared for pastoral farming in the late 1800's and early 1900's (Laffan and Daly, 1985). By 1915, over 50% of the land had been logged or burnt and was in pastoral use. A proportion of this has subsequently reverted to secondary growth (Lauder and Kirk, 1985, P.119) due to the high rainfall in the area being conducive to fast growth of shrubs and fern (Bowie, 1963). Also, over-stocking and over burning has influenced the destruction of the land resource (Bowie, 1963).

The first planting boom in Marlborough, as elsewhere in the country occurred during the 1920's, 1930's. The first exotic forest plantings in the Sounds were by Chichester in the 1930's (Farnham Forest) and then the Rai Forest was planted from the 1940's. Until the 1960's only small woodlots and shelter planting's were established as farming was the main form of landuse (Bowie, 1963). In the 1960's government inducements prompted forest establishment and a concentrated planting effort was made in the Tory Channel- Port Underwood locality and the Havelock/Pelorus/Wakamarina locations (Marlborough District Council, 1992).

The second boom (in the 1970's) saw the New Zealand Forest Service carrying out large scale planting throughout Marlborough. Figure 4.2 shows the planted forest area of the Sounds by 1995 (Leslie, 1995). In 1987 all the region's state-owned planted forests came under the management of New Zealand Timberlands Ltd, the forest-growing subsidiary of state-owned enterprise New Zealand Forestry Corporation Ltd. Most state-owned natural forest in the region was assigned to the Department of Conservation. Since 1990, the government has sold most of the state forest assets, including forests and land improvements, to forestry companies. It has also granted Crown Forestry Licences, which grant the right to harvest existing forest and establish new forests (Ministry of Forestry, 1997).

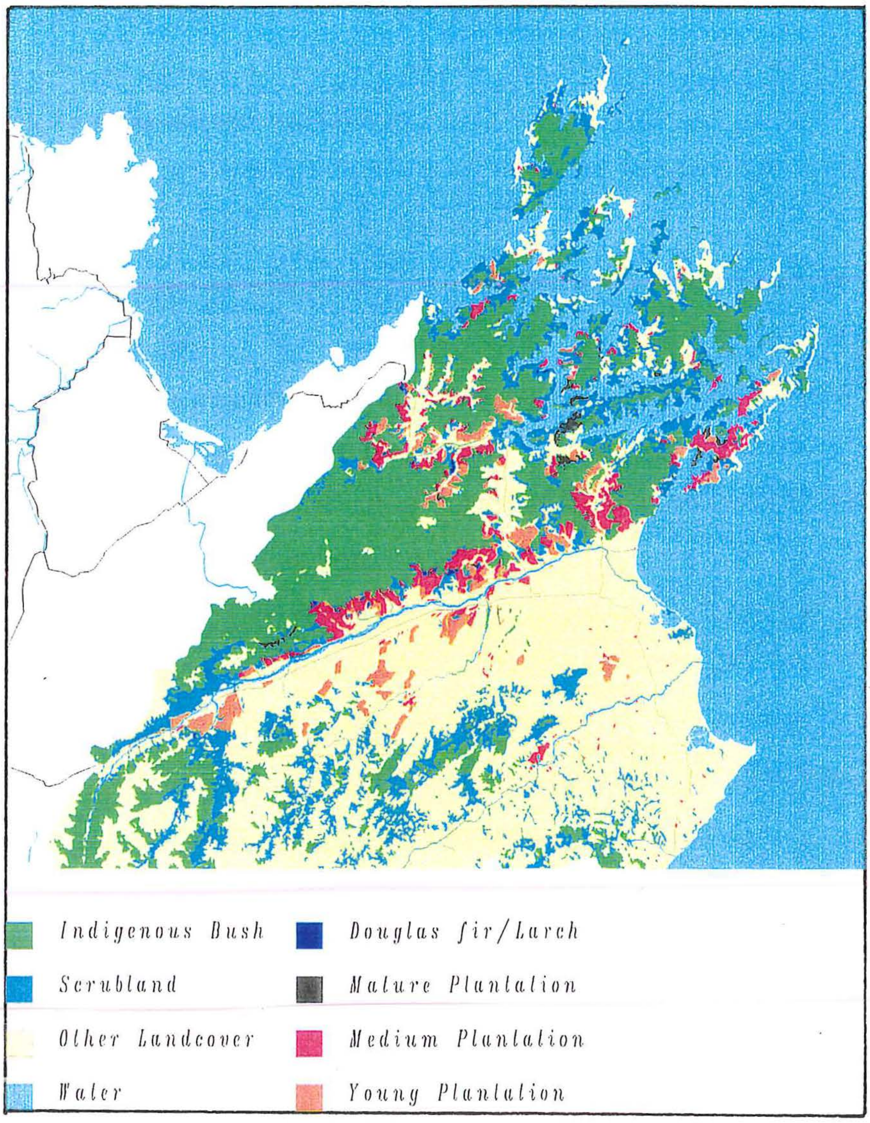


Figure 4.2: Classified satellite forest cover for Marlborough (Leslie, 1995, P.6).

Forestry practises in the past, for example site preparation, involved line dozing and root raking techniques on steep hill country resulting in damaging on site and off site effects, including increased silt laden runoff, soil erosion and marine sedimentation. The logging of Farnham Forest, Tory Channel, Queen Charlotte Sound, where management of forestry practises was not undertaken to high environmental standards, led to the effects of forestry on the coastal zone being highlighted. The community became concerned about forest development in the Sounds at this time. Severe land stability problems and sedimentation set the forestry industry in Marlborough back at least a decade (Marlborough District Council, 1992). Hard lessons were learnt but this led to significant improvements in forestry practises. The industry moved away from tractor and skidder ground based logging and crude, high lead hauler systems on steeper hill country to more sophisticated partial and even full suspension cable and skyline systems, limiting detrimental effects.

Community concerns from forestry include:

- damage to indigenous flora and fauna through change of habitat and land clearance,
- erosion and land stability hazards from disturbance activities (for example, road building or land clearance),
- exotic weed entry after stages of land clearance or wilding pines out-competing native bush,
- degradation of soil resources in areas where topsoil is lost or where soil conservation practises have not been carried out,
- fertiliser use contaminating waterways,
- adverse landscape and amenity repercussions of site clearance, logging and exotic species rather than native bush,
- biological contamination of shellfish (both wild and farmed) by sedimentation of coastal waters following clearance for planting, tracking and logging,
- reduction of stream flows during forest establishment,
- loss of potable quality stream water during and after land clearance and logging,
- physical damage to the public foreshore reserve,
- coastal space occupation during logging and log loading, with the potential for interference with other resource users such as marine farmers and recreationalists.

(Marlborough District Council, 1992).

4.4 Why forestry as a landuse in the Marlborough Sounds?

4.4.1 A sustainable/versatile land use

The trend of plantation forestry in New Zealand today, is the planting of P. radiata in areas previously used for farming. Conversion from indigenous forests to pine plantations is not on the agenda any more as the conversion is costly due to land clearance difficulties. The pessimism about the future for farming is a result of, among other things, the declining market for meat and wool, especially since Great Britain joined the European Union. The argument is that pasture is both economically and ecologically unsustainable land-use (for example; soil erosion, decline in soil fertility and increasing problems with weeds) (Maclaren, 1993). However, forestry also has unsustainable effects such as loss of soil stability, soil fertility and reduced biodiversity. However, the economic return from forestry is better and for much of the growing period forestry is sustainable.

Marlborough's Site Index for radiata pine is 27 (Site Index is the tree height in metres at the age of 20 years). The region is producing volumes of 450 to 700 cubic metres per hectare at age 30 years. This is high by world standards. Radiata pine is a versatile species as it:

- will grow in soils from sand to clay,
- can withstand frost and mild salt spray,
- does not require much rainfall (600mm/annum),
- is fast growing,
- produces timber that is easy to dry and treat,
- has good nailing, gluing and painting properties,
- is suitable for a wide range of uses

(Ministry of Forestry, 1994).

4.4.2 Infrastructure

Major infrastructure requirements to support forestry and wood processing in Marlborough are road, rail and sea transport, energy, water, land and labour. Figure 4.3 shows the infrastructure in place in Marlborough to accommodate forestry, including major ports, railways, saw mills and roading. The Sounds roading network is not of a high standard, therefore tug and barge services operate to transport logs from forests to Nelson, Picton or Havelock for further transport to local mills for processing or log export. Log rafting (where bundled logs float in water) is not permitted due to the danger of water contamination and impact on the marine farming industry (Ministry of Forestry, 1997).

Major wood processing plants require a reliable electricity source. The national suppliers, Contact Energy and Tranzpower, in combination with local electricity generation is sufficient. Wood waste is commonly used as an energy source for drying kilns and heating water (Ministry of Forestry, 1997).

Water is a critical factor in establishing processing industries in Marlborough. Other issues for water use include effects on stream flows and groundwater recharge. Land required for wood processing industries must be flood-free, flat with good foundation, have an adequate water supply and located away from urban areas but reasonably close to the labour force (Ministry of Forestry, 1997). There are a number of processing plants already in the region that fit these necessities.

The main trunk railway line is close to the Sounds (Figure 4.3). This links to the south through Christchurch and to the north via the interisland ferry service. The area has major sea transport through Ports at both Nelson and Picton, which have a wide range of facilities to handle log and timber exports and the new port at Shakespear Bay has been constructed to handle the predicted influx of logs for shipping offshore.

The Marlborough area has assets to encourage future development. In terms of soil suitability, Molloy (1988, cited in Ministry of Forestry, 1995, Johnston, 1981), estimates that up to 40 000 hectares of Marlborough Sounds land are suitable for planted production forestry without impacting on the natural forest landscapes.

4.5 Is forestry appropriate for the Marlborough Sounds?

Estimates of land appropriate for forestry in the Sounds differ substantially. The regional survey of Marlborough 1962 by the Ministry of Works suggested that at least 12,140 ha of land in the Sounds county could 'adequately support exotic plantations'. However the survey also noted;

a) 'complicated land tenure patterns and the presence of large reserves which precluded the establishment of extensive areas considered necessary to be economically successful. Small, disconnected areas of forest would result in "excessive managerial and transport costs",
b) suitable planting areas were often exposed to strong winds,
c) land prices are high and cost of acquisition often prohibitive,

d) access by water being circuitous so the transport of logs would be difficult and expensive' (Ministry of Works, 1962, cited in Field, 1976, P.27).

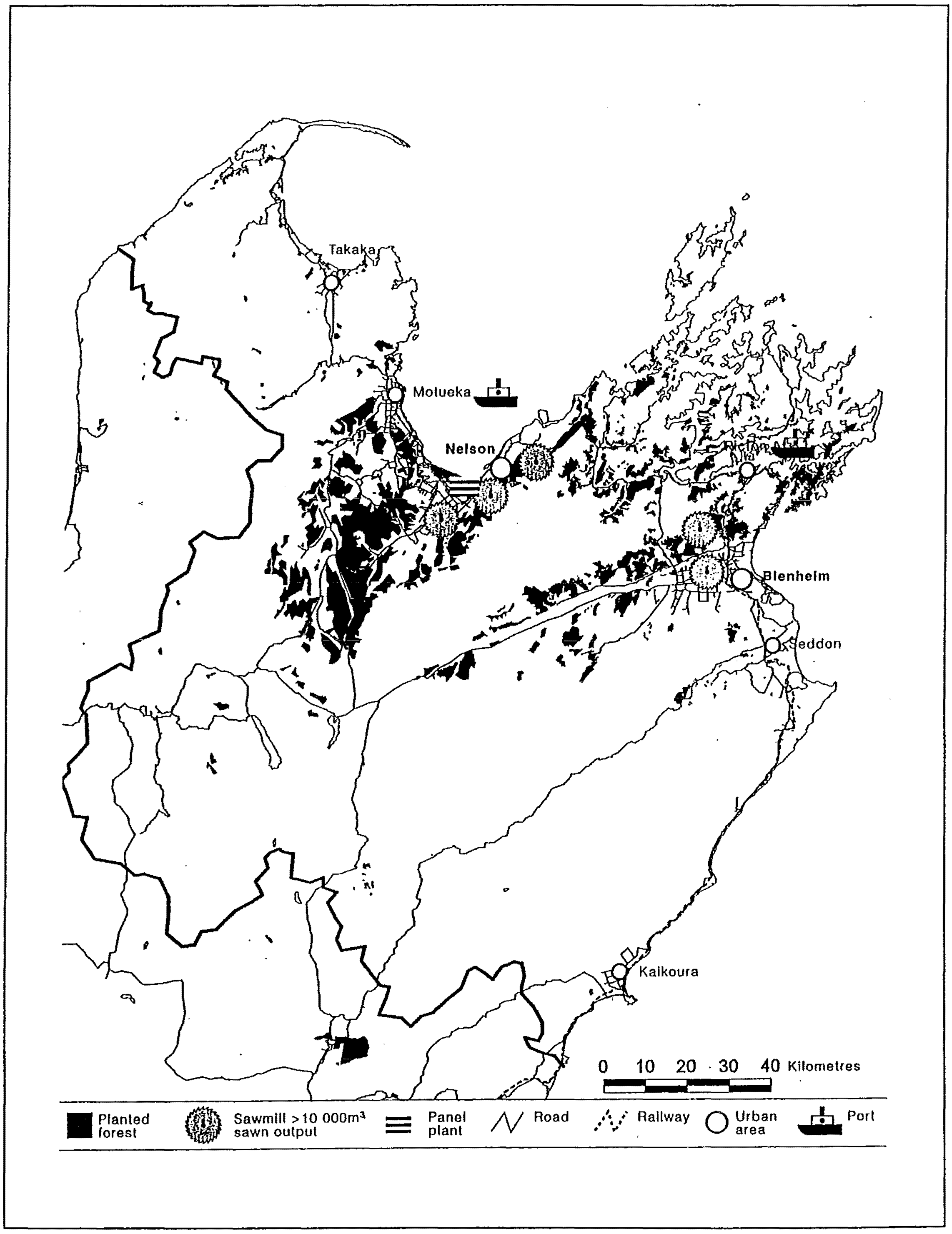


Figure 4.3: Infrastructure in place for the Marlborough Timber Industry (Ministry of Forestry, 1997, P.16).

Laffan and Daly (1985), estimated (based on present vegetation patterns) that 40,000 ha of mainly hilly and steep land are suitable for afforestation in the Marlborough Sounds. Physical limitations result from steep slopes having a low soil depth and texture and the abundance of rock outcrops on spurs and rocky ridges.

The Marlborough Resource Management Plan, (1994) outlines the land use capability of the Sounds. This is shown diagramatically in Figure 4.4. Each capability class is broken down into subclasses depending on the limitation to use. Limitations are: erosion (e), wetness (w), soil fertility (s) and climate (c). Land use capability classes 1-4 are arable lands on slopes less than 20°. Classes 5-6 are non-arable lands, which have moderate limitations to productive use. Class 7 is non-arable land with severe limitations to productive use and Class 8 has extreme limitations, and production on this land is not appropriate. Figure 4.4 suggests that most of the land area in the Marlborough Sounds is highly unproductive and land use capability is low, as shown in the green and red areas of the map. Only in isolated pockets usually at flatter bay head locations is land use capability high.

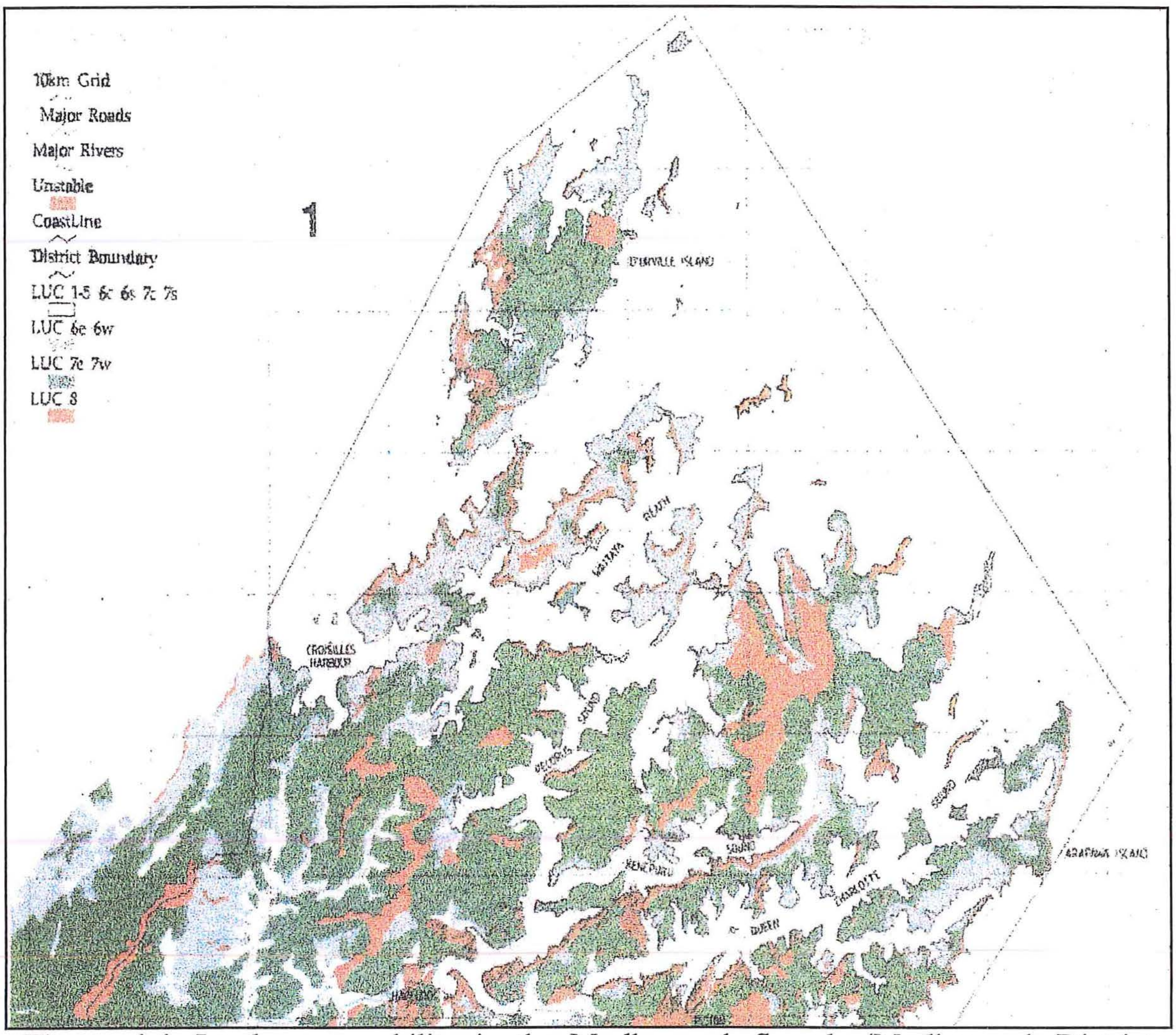


Figure 4.4: Land use capability in the Marlborough Sounds (Marlborough District Council, 1994, P.25).

Most of the exotic forestry plantations in the Marlborough Sounds are on slopes greater than 25°, on soils that have a high potential for releasing fine sediment when disturbed (due to their high clay content and low aggregate stability) (Fahey and Coker, 1992). Soil nutrients are limited in phosphate and nitrogen. Soil deficiencies can be overcome by burning or topdressing forming a short-term nutrient supply prior to planting (Laffan and Daly, 1985).

The soils are well suited to the establishment and growth of radiata pine. At altitudes below 550m metres, most soils have only slight physical limitations as discussed above and moderate nutrient limitations of Phosphorous deficiency for the growth of pine trees (Laffan and Daly 1985). Over much of the growing cycle forestry will be beneficial for soil stability and water quality. However during harvesting operations, site preparation and construction of access tracks have varying impacts on site disturbance and soil erosion. Laffan, McQueen, Churchman and Joe (1985) found that impacts are likely to be greatest on thick regoliths at altitudes below 200m, and these sites require special planning and management practices.

There has been particular concern over the potential for increased soil erosion, water pollution and sedimentation resulting from commercial forestry operations which could adversely affect other uses such as marine farming, recreation, fishing and residential development. These issues are relatively specific to the Marlborough Sounds area and will be discussed in the following section.

4.6 General effects of forestry in the Marlborough Sounds

There are a number of effects exotic forestry have on the environment including evapotranspiration increase, rainfall increase, albedo changes, water turbidity increase, water nutrients increase, water temperature increase, depth of water table decrease, soil acidity increase, erosion increase, soil moisture decrease, elimination of arborescent and undergrowth vegetation, fish and small mammal habitat decrease.

These changes in the environment are not necessarily perceived as negative or positive but they do change a catchment and the surrounding land or waterways. The following section describes some of these changes and their subsequent effects. It is noted that through most of the growing process, exotic forestry is beneficial to the environment. However during harvesting or site preparation effects of forestry are most 'felt'.

4.6.1 Visual impacts

With such a large proportion of New Zealand under forest (approximately 30%), forests and forestry play a major role in the New Zealand landscape so particular attention must be given to the ways in which they are managed. There are multiple reasons for public objections to commercial forestry, but visual impacts are a very substantial contributor. As much of the public's only interaction with forests is visual, observing forests from roadsides, trains, planes, ferries, or private boats, managing the visual image of forests is very important. Visual impacts may pose threats to other uses such as tourism, and public perception of threats to the environment. Visually, exotic plantations do not have the pull of native forests. This is probably due to the grid pattern and the lack of variety of species (Potton, 1994). Visser and Smith (1993) suggest that visitors are most critical of visual impacts as their responses will be dependent on their expectations of the forest.

The study 'A Strategy for the Conservation and Development of the Sounds' (Ministry of Works, 1976) gave high weighting to the aesthetic importance of the Sounds landscape. An objective stated in the report is to 'ensure that peaks, headlands, peninsulas, prominent faces, necks enclosing important reaches and ridges and skylines, which are vital to the Sounds landscape, are protected from development'.

Areas of concern for aesthetic effects of exotic forestry include the zig zag scars on the hillside from roading and tracks which are discordant with natural contours. During forest establishment aesthetics may be impacted from smoke from fires. During logging, clearance of the natural vegetation stands out in the environment as the sandy coloured clay soils contrast with the green areas of native bush.

Rogers, (1996) found that New Zealander's viewed exotic forestry as a positive feature, important to the quality of the New Zealand landscape as it provides amenity values, recreation values and economic values. These aspects of an exotic forest can reduce the use pressure on New Zealands' native forests, hence preserving their features.

Forestry personnel readily accept visual impacts because they are familiar with the forest cycle. The resource they are producing is renewable and the need for forest operations is an inevitable consequence of the process of production. Foresters' perspectives on the resources stretch over at least one rotation (25 years or longer) and visual impacts are considered short term and a minor impact from the process (Visser and Smith, 1993).

4.6.2 Soil erosion

Conversion to Pine forests can prevent growth of stabilising grasses and other vegetation due to the intense shade. This can lead to increased erosion, as soil particles are not locked together with a strong rooting system. During the growing process, trees will be beneficial in decreasing erosion by protecting exposed ground from raindrop impact and by increasing the rooting system network, especially in the subsoils. However, during and after clearance, rain interception does not occur resulting in the potential for sediment to be entrained by water and carried to bays and coastal inlets via streams.

The Marlborough Sounds soils on the steep mountainous landscape have the potential to be highly sensitive to erosion (McQueen *et al.* 1985). Soils at higher elevations (above 200m) have a lower erodibility than those at lower elevations (below 200m). These lower soils have been formed from strongly weathered greywacke and schist, including soft saprolite, and are highly dispersive and erodible, and have the greatest potential for the production of fine sediments (McQueen *et al.* 1985). This suggests that roading activities should not be at low elevations due to the potential of this land use to produce large amounts of sediment. The importance of roading in erosion processes is highlighted in studies by Coker (1994), shown in Table 4.3. Roading surfaces below 200m resulted in very high production of coarse and fine surface sediment.

Table 4.3: Sources and amounts of surface sediment from different forestry land practises in the Marlborough Sounds (Coker, 1994, P.32)

	Distance (m)	**Sidecast**		**Surface (above 200 m)**		**Surface (below 200 m)**	
		coarse	**fine**	**coarse**	**fine**	**coarse**	**fine**
Roads (old)	500	7.87	1.10	0.90	0.99	0.67	3.10
Roads (new)	2900	106.92	6.05	4.16	5.44	4.26	18.63
Contour track	1000	-	-	-	-	0.25	10.35
Fire-breaks	1000	-	-	1.35	0.74	3.82	8.79
Total	5400	114.79	7.15	6.41	7.17	9.00	40.87

Soil erodibility is greater for subsoils than topsoils (McQueen *et al.* 1985). This has implications for forestry as a landuse, as much of the subsoil is exposed in logging and roading practices leading to greater erosion potential. Roading in timber extraction is regarded as one of the greatest producers of sediment, far above the use of fire or logging. Roading as a landuse results in the removal of topsoil, leaving the subsoils exposed to environmental factors leading to erosion.

4.6.3 Nutrients

Cutting or burning of forests can provide significant amounts of nutrients to surrounding waterways often in the form of phosphorus and nitrogen. Nutrient loss of the soil also occurs as a result of harvesting the whole tree (including branches and needles). To minimise nutrient losses it is recommended by Balneaves and Dyck (19992, cited in Maclaren, 1996) that as much slash as possible be left on site. This may not be entirely convenient in the Marlborough Sounds' context as much of this material has the potential to fall into neighbouring watercourses, becoming a hazard to water users, polluting the water and fire threat to houses and adjacent land uses.

Nutrients from forestry practises is beneficial to water uses such as fish farming. The nutrients that run off the land are filter fed through the fish and aid in the organism's growth. However, an increase in water nutrients can increase the frequency of algal blooms that subsequently compete with fish for nutrients leading to fish being contaminated by the bloom. Ideally nutrient runoff should be monitored in order to control the possibility of algal blooms, that threaten other resources such as the rapidly growing mussel industry.

4.6.4 Stream flows

When logging practises are carried out the water regimes of the catchment are changed in a number of ways. These effects are an increase of stream peak flows and increased runoff. Stream flows increase after logging or burning because of a reduction in the quantity of water evaporated from the catchment. Plant transpiration is reduced and the quantity of rainfall intercepted by vegetation and consequently evaporated is also decreased. These reductions may to some extent be counteracted by an increase in the water evaporated from the soil surface because of higher wind velocities and soil temperatures (Steombrenner (1996) cited in Morgan and Graynoth (1978)).

Logging roads and skid tracks have compacted impermeable surfaces. During heavy rainfall excess water, unabsorbed by the surface can flow directly into stream gullies. It was found by Hsieh (1970 cited in Morgan and Graynoth, 1978) that volume of flood peaks in the Oregon Coast Range, increased significantly when 12% of the catchment area was in roads but only minor changes occurred when 3%-4% was in roads.

4.6.5 Water quality

Water quality depends on the landscape's ability to collect and purify water. In addition, natural vegetation helps to reduce floods and retain soil. A decrease in vegetation leads to an increased potential for water quality to become low (O'Neill *et al*, 1997). Water quality is important to monitor and manage for:

- aquatic ecosystem protection,
- fishery purposes
- fish spawning purposes
- gathering or farming of shellfish
- contact recreation and bathing
- retaining them in their natural state
- aesthetic purposes
- cultural purposes

(Marlborough District Council, 1992).

Water quality is reduced during material burn off, chemical spraying of fertilisers, herbicides and poisons, disturbance of debris caused by felling alongside water courses and by silt and sediment run off from fire breaks, roading, land preparation and harvesting (Wilks, 1980). It has been found that road construction has the greatest impact on sediment yield during the forestry cycle (O'Loughlin, 1985) and hence effects water quality the most.

O'Loughlin, (1980) collected seawater at two sites offshore of Farnham Forest after a harvesting operation: one offshore from a steep area that had been clearfelled, and the other offshore from an unlogged stand of Pinus radiata. Both were opposite small streams. He found that the area logged had a suspended sediment concentration in excess of 13,000 ppm compared to only 30 ppm in the stream from the unlogged area.

Two points emerged from this study; concentration of sediment from flooded streams influenced the near-shore region and these sediment loads cleared over periods of less than 24 hours by dispersion or flocculation.

4.6.6 Sediment

Road building, logging, side casting, and burning can increase soil erosion rates and lead to exceptional amounts of insoluble inorganic material (sediment) entering streams. These forestry practises increase erosion by removing vegetation, disturbing and scarring the ground surface, and exposing the soil to weathering effects. Soil compaction by timber, machinery, and rainfall can increase the quantity and velocity of surface runoff, which transports eroded sediment downhill to the stream.

The weathered soil of the Marlborough Sound's, erodes readily providing material that is easily transported, via streams to the coastal zone. Due to limited wave and tidal action, this material is not readily transported offshore; instead it is deposited as a mantle over the seabed (Johnstone *et al.* 1981).

Fahey and Coker (1992), found that in Queen Charlotte Forest (in Tory Channel), most of the mobile coarse material above two hundred meters elevation came from road surfaces. They found drainage ditches and cutbanks were not major contributors. They estimated that 5-10 t of fine sediment is removed annually from each kilometre of road. The sediment suspended in runoff water is expected to rise to 100 $t.km^{-2}.yr^{-1}$ at peak harvesting times. Fahey and Coker (1992) predicted that this sediment may find its way to coastal inlets via local streams within hours or even minutes of being mobilised.

The estimation of sediment runoff from catchments varies in relation to topography, landuse and soil type hence other studies in different areas have produced some very different quantities of sediment. Mosley, (1980) found in south west Nelson, erosion rates of 710 t km^{-2} of roaded area per year, Fahey and Coker, (1989) found erosion rates of 37 t km^{-2} of surface erosion in Motueka forests. The Marlborough Sounds sediment runoff will be highly dependent on the forestry practises chosen and exposure to environmental factors such as wind and rainfall.

Megahan and Kidd, (1972) found from a forest in Central Idaho that logging operations alone (excluding roads) increased sediment production by a factor of about 0.6 over the natural sediment rate. They also found that roads associated with the jammer logging system increased sediment production an average of about 750 times over the natural rate for the six year period following construction. This data shows interesting statistics on the amount of sediment produced from various forestry practices.

A study by Murphy (*et al.* 1991) showed that by reducing the impacts of harvesting practises (increasing constraint levels), in particular roading and logging, a reduction in suspended sediment results (Figure 4.5). Note that the Pelorus river has an estimated specific sediment yield of 319,158 t/yr (Griffiths and Glasby, 1985, P.776), therefore the level of sediment load shown at a low constraint level in Figure 4.5 may be environmentally acceptable as sediment levels are already high in the Sound.

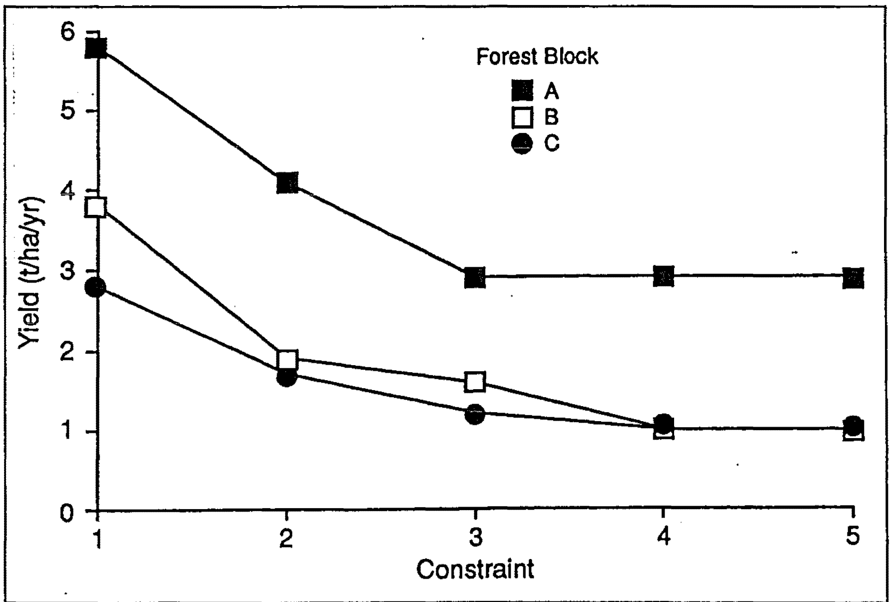


Figure 4.5: Effect of increasing environmental constraint on total sediment yield (Murphy *et al.* 1991, P.18).

The large amount of suspended sediment found in the Pelorus Sound is not only present because of forestry but also because of the slow overall flushing rate of the Sound, resulting in a lack of sediment being transported out to Cook Strait. The hydraulic residence time in this coastal inlet is long (21 days) leading to sediment build up in bay heads (Lauder, 1987). Sedimentation of an area in the Pelorus Sound, may not be solely due to catchment processes in that bay, but can be from catchment processes in the

Pelorus River catchment or adjacent bays, that, with the aid of tidal and wave processes can result in sediment transport to other areas. Sediment is transported at a rate dependent on water velocity and sediment size and deposited when water velocities drop. Velocities may decrease as slope decreases leading to deposition of sediment (especially easily transported fine silts and clays) on the beach.

Sedimentation from forestry practices conflicts directly with the value of water for marine farming, amenity use and marine ecology. These effects may be short term for water clarity but have the potential to have longer term effects in seabed smothering.

4.6.7 Flora and fauna

Both fresh water, marine and land dwelling communities are influenced by forestry practises. Teows and Brownlee (cited in Weetman, 1983) have charted some of these relationships shown in Figure 4.6. Figure 4.6 shows that both flora and fauna are influenced in a number of ways from forestry practices including both logging and site preparation.

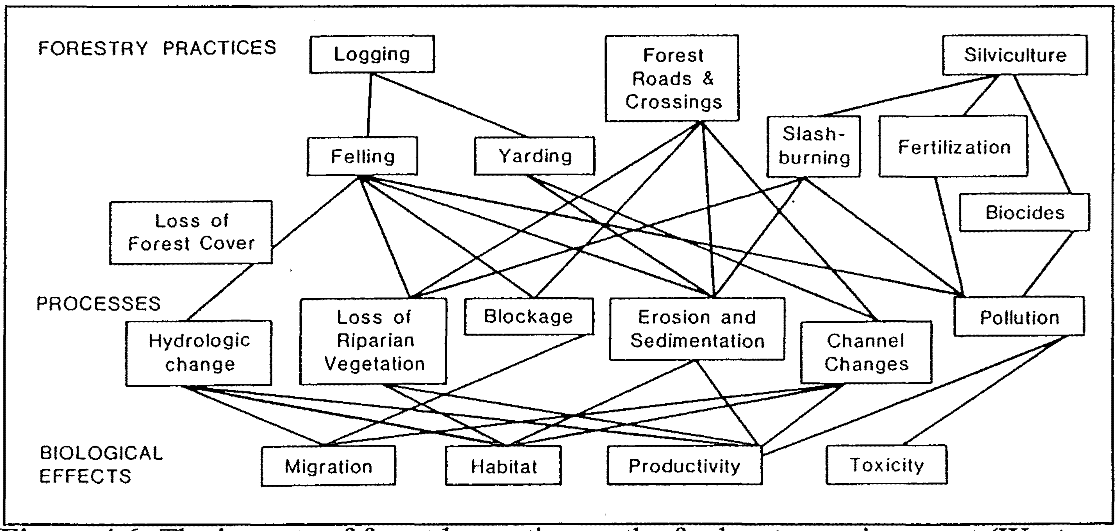


Figure 4.6: The impacts of forest harvesting on the freshwater environment (Weetman, 1983, P.295).

Decaying debris in the water in large amounts may lead to less oxygen available for fish. This debris could improve a fish's environment as it can increase food supplies. Shading from exotic forests can decrease water temperatures in the bay. This will vary depending on aspect, time of year and age of stand. After logging the amount of radiation on the water may be a lot greater affecting the type of flora and fauna inhabiting the bay. Red algae (Rhodophyta) and mosses are adapted to grow in shaded forests, but unicellular and filamentous green algae require high light intensities (Morgan and Graynoth, 1978). Several sprays may also affect flora and fauna both in the waterways and nearby the block on land. This aspect of forest effects is important due to the amount of recreational fishing in the area – an important water use which can conflict with forestry.

Small amounts of sediment can have subtle effects on fish ecology; large amounts can be fatal both to fish and their food organisms (Morgan and Graynoth, 1978). Studies by Johnston (*et al.* 1981) found that after the logging of farming forest extensive siltation of Bays adjacent to logging catchments occurred. At these sites fauna was 'impoverished apart from some horse mussels and scallops and a few species of animals feeding on decaying tree detritus… but most of the animals were dead' (Johnston *et al.* 1981, P.7).

Siltation reduces the productivity and diversity of marine life by smothering small bottom-dwelling species, decreasing light penetration and preventing settling of plants and animals (Johnston *et al.* 1981). It is not known how long these fine sediments remain on the seabed. However it is suggested by Johnston (*et al.* 1981) that due to the long mean residence time, it is likely that this sediment will remain in the Sounds rather than be carried out to Cook Strait.

Vincent (*et al.* 1989) found that dissolved substances exert a strong influence on the underwater light field in Pelorus Sound. It was found that most of the effects were at the blue end of the spectrum and are hence related to the absorption by wavelength dependant dissolved organic materials and by particulate organic matter. This suggests that areas in the Pelorus have a high percentage of organic materials in suspension, blocking blue light to deep areas. This may influence flora in photosynthesis.

Exotic forestry may destroy or adversely affect indigenous successional vegetation. Regenerating vegetation although perceived by most to be scrub and unuseful, is being increasingly appreciated as a bird habitat. Wilding pines are a direct threat to vegetation and can out-compete most native species for light and water. Forest owners should accept some responsibility for preserving the character of the surrounding landscape by controlling wilding pines. It is difficult however, to establish which plantation the stock came from. Different species of Pine are more or less susceptible to regenerating and focus to date is to generate a sterile radiata pine planting stock.

4.6.8 Conflicts in resource use

Competition for space may be an effect of forestry's presence in the Marlborough Sounds. Natural vegetation that has regenerated to an advanced stage is more beneficial to be kept as a reserve. This is due to land clearance being too difficult and the nature of the bush being important in order to maintain genetic diversity and diversity of different types of land use around the Sounds.

Forestry could conflict with the resource use of reserves. These reserves are important for the protection of native habitats and the wildlife that inhabits them. They are also important for recreational purposes. If exotic pines lay adjacent to a reserve, wilding pines can encroach on native areas and out compete native species. Fires used in land clearance have the potential to become out of control and burn native bush. Roading for harvesting access may need to pass though reserves or be adjacent to them and the view for those using the area for recreation may not be aesthetically pleasing even at a mature stand stage in the forestry cycle as this conflicts with users wishing to be in a totally native, natural environment that also has historical ties (Field, 1976).

Recreation is a major use of the area and can conflict with forestry in area use due mainly to aesthetics. Visual problems effecting recreation include water discolouration, floating debris (branches and logs), changes to the skyline during harvesting, and landscape alterations such as roading and tracks (Field, 1976). Physical problems include, air pollution from fires, noise during harvesting from tractors, chainsaws and extraction equipment and decreases in water quality. Recreation could be carried out on the South facing slopes because forestry is using the sunny north facing slopes but this results in most of the lookouts to the opposite catchments being on forestry rather than native bush. Problems could also occur with people recreating on or near forested land. Fire is a huge risk for forestry and many landowners do not allow people to use their land for recreational purposes for that reason.

Recreationally forest plantations have become an excellent venue for off-road activities like horse riding, mountain biking and walks. Thus they create a great place for activities that normally could impinge on the use of our indigenous estates (Potton, 1994).

Shading from adjacent lands could affect residential development, as could other forestry practises mentioned earlier such as air pollution from fire, aesthetics during logging and noise from harvesting.

Conflicts between forestry and marine farming are important issues due to the economic potential of marine farms as a water use. Mussels require water of high quality in order to flourish. Chemical spraying, fertilising, or land preparation is not an immediate threat to seawater quality in the Sounds. However, Mussels can be affected by high sediment loads from forestry practises. Clearfelling systems that involve the removal of the overhead canopy and large disturbance of the soil, have a direct result in increasing runoff and contribute to additional silt loads in neighbouring water ways (Wilks, 1980). These smaller sediments have the ability to kill Mussels and can expend much of the mussels energy on the expulsion of silt rather than on growth (Field, 1976, Johnston *et al.* 1981)). It was found by Wilks (1980), that Mussels subject to medium-high levels of suspended sediment for more than six hours will die within 48 hours. Larvae die due to blocking of the digestive tract. However, sediment can also be beneficial to mussel farming. About half the nutrients that enter a stream or waterway do so by attachment to sediment (Brown, 1973, cited in Wilks, 1980). These nutrients are used for mussel growth.

Planning times of logging must not coincide with mussel harvesting or early growth. Ideally careful planning should insure that mussel farming and forestry are not located close to each other or legislation must be put in place to restrict logging activities on adjacent water uses. However, in the last three years there has been substantial logging of forests adjacent to marine farms and there has been little impact recorded by marine farmers on the productivity of the marine farm assets. It is noted that after storm events in catchments draining forests that any sedimentation is localised and sediment is flocculated out of the water column in most circumstances before encountering the marine farms which are located normally beyond 50 metres of the mean low water at the shore. In the Pelorus Sound large floods from the Pelorus and Kaituna Rivers have a significantly great impact on sediment production that affects marine farms and causes closure of mussel harvesting for the industry (Ron Sutherland *pers com*, 2000).

4.6.9 Impacts on Tangata Whenua

Impacts on Tangata Whenua and their relationship with ancestral lands, and in particular on waahi tapu and other taonga (including shellfish and other traditional food gathering) is important in the planning of forestry in the Sounds. Scatterings of Maori historical sites lie in almost every bay in the Sounds due to the areas large inhabitancy in pre-European times. These areas, if not placed under a historic reserve, should be regarded with integrity and treated with utmost respect.

Archaeological sites that show evidence of human activity of an age greater than 100 years are automatically protected whether or not the site has been recorded under the Historic Places Act 1980. The Act makes it an offence to damage the sites without authority from the Historic Places Trust. It is important forest planners consult local iwi if cultural sites are believed to be present on the area, as conflict could arise, resulting in delays, bad publicity and possible court action.

4.7 Effect of forestry on the coastal zone – A small study

An important aspect of coastal behaviour in the Marlborough Sounds stems from linkages between catchment and coast (Lauder, 1987). This small study focuses on the effect of different land uses on the coastal zone, looking specifically at the effect of changes in catchment on the fine sediment levels in both the water and seabed in the embayment.

Fine sediments are potentially significant due to the high clay and silt content of the Sounds soil (Lauder and Kirk, 1985). Johnston (*et al.* 1981) predicts that subsoils have values of 40-50% clay and 40% silt. These sediments have the capacity to modify the character of the shoreline environment (Lauder and Kirk, 1985). Six types of catchments were studied. They were, forested, currently logged, recently logged, recently planted, native forest and farmland.

4.7.1 Methodology

Sites were chosen in the Pelorus Sound that had a range of different landuses, in order to contrast the different landuse effect on the coastal zone (Figure 4.7, shows the sites chosen). At each site dredge samples were taken, secchi measurements recorded and general observations were made.

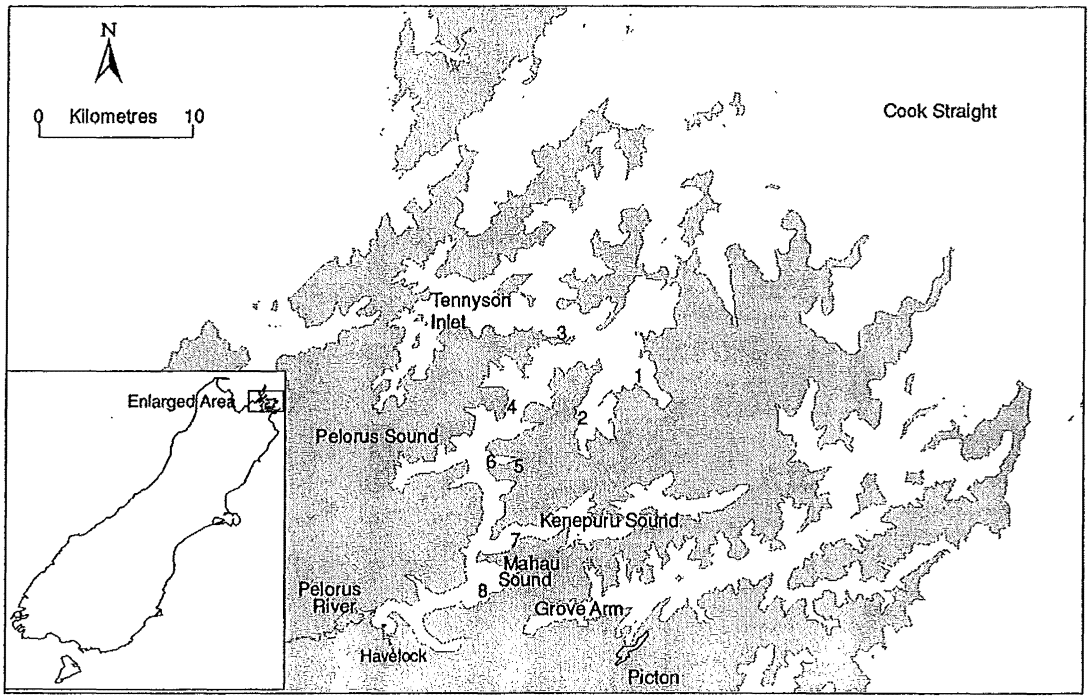


Figure 4.7: Map showing study sights in the Pelorus Sound.

A Secchi Disc is a weighted circular plate, with alternative quadrants painted black and white (Figure 4.8). It is 20cm in diameter and is lowered into the water to show a measure of water quality through transparency. The depth where the secchi disc is out of sight and comes back into view is averaged to find a depth in metres. Secchi disc measurements were recorded between 10am and 3pm to reduce the error due to the suns angle, with different amounts of light penetrating the water. Secchi disc depth values are significantly reduced by the suspension of sediments. K is the diffuse attenuation coefficient (the extinction of daylight with depth in the sea) and is formulated by 1.45/d where d is the maximum depth in metres at which the disc is visible (Tait, 1981). A low

K value signals a high visibility hence low suspended sediment concentrations in the water.

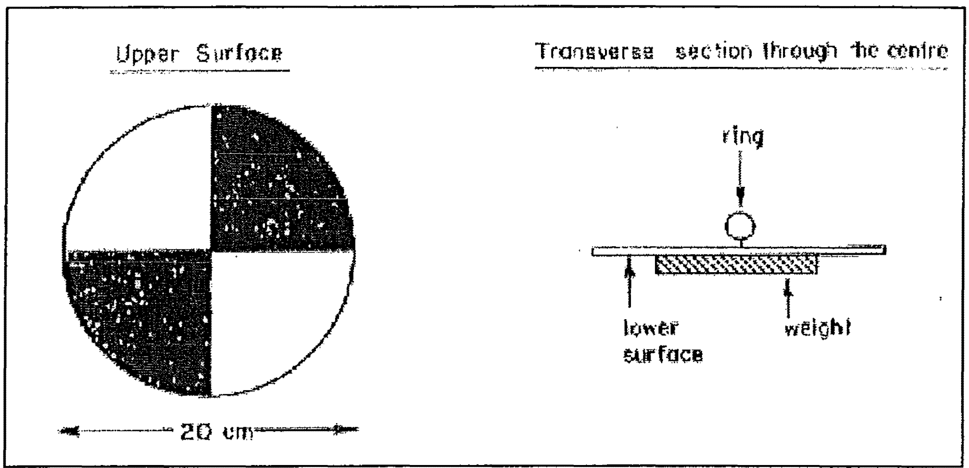


Figure 4.8: Secchi disc dimensions and construction.

At each site dredge samples of bay floor sediment were obtained. These samples are examples of surface sediment and reflect the existing conditions of a bay. Coarse sediment in the Sound remains on beaches and the finer material is in suspension or on the bay floor. This fine material is transported off the catchment as it is easily suspended in water. The dredge sample was made from the nearshore to the outer shore in a line. Some bays had a floor which was coarse, prohibiting dredging. In some bays two samples were obtained. This sediment was sieved and silts and clays were put through hydrometer analysis to find the percentage composition of sediment size per sample. Fine sediment was of primary concern as this is more easily transported to the coast from the catchment and much of the catchment sediment is made up of this size fraction.

4.7.2 Results

Site one: Clova Bay - this site had been logged within the last five years and had no riparian strip, therefore has no buffer to the coast. This site was expected to have high levels of sediment in its bay due the lack of protection of the coast from runoff (Plate 4.2). There has been no clean up of this site since logging and a discarded slash is present on the slopes and is concentrated in gullies as shown in Plate 4.3. This can cause ponding of water as water builds up behind the slash and in times of high rainfall can lead to mud sliding (Plate 4.4 shows an example of poor drainage in Crail Bay). This site surprisingly had a small percentage silt/clay proportion in the dredge sample. This may be due to the higher energy outer Sounds environment relative to other sites. Secchi disc measurements showed that the water had low suspended sediment concentrations. The offshore secchi disc results (K=0.29) indicated a lower visibility than near shore (K=0.26). This may have been due to an adjacent mussel farm contributing to suspended sediment in the form of mussel effluent.

Plate 4.2: Site 1 Clova Bay, showing slash material being deposited in the coastal zone due to no riparian strip being present.

Plate 4.3: Site one (Clova Bay) showing slash debris concentrated in the gully.

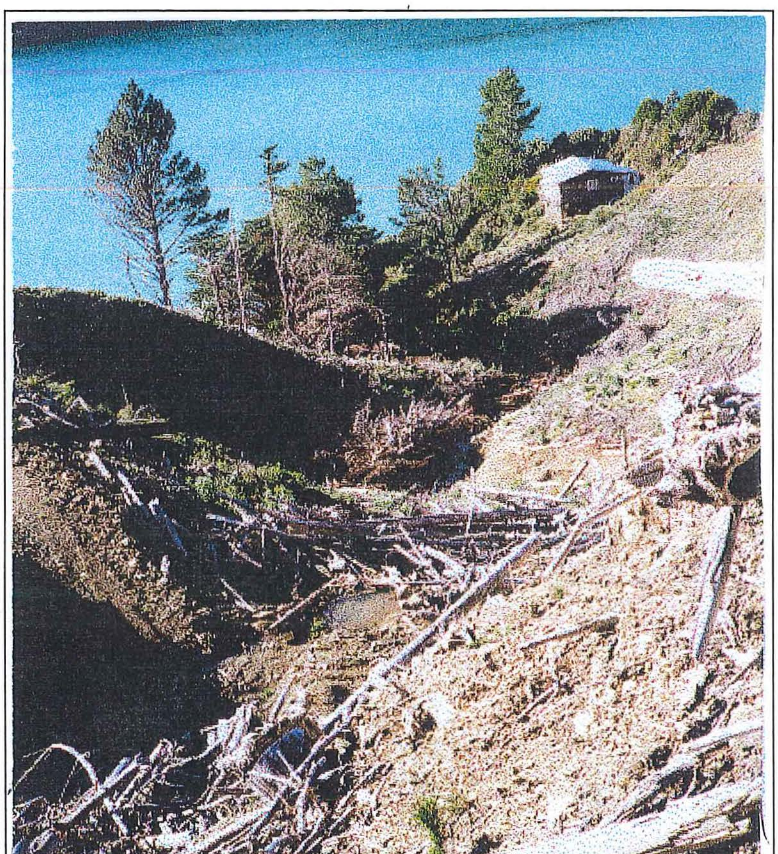


Plate 4.4: Build up of water behind slash material Crail Bay.

Site two: Wet Inlet, Crail Bay- This site was logged in the last five years and has been replanted in P. radiata (Plate 4.6). Plate 4.5 shows a platform collapse and debris deposition in gullies. Data from the Marlborough District Council relayed how this site was damaged in 1998 by a storm event which led to cut batters of tracks, slip movements and soil and slash material being deposited in tracks diverting stream water. Two dredge samples were taken at this site, the first in front of a tributary from a large catchment and the other 30-35 metres offshore. The bay floor sediment close into the shore was coarse and no clay and little silt was present in the dredge sample. Offshore the sediment was more sorted and was comprised of only sand and silt. This finding is in keeping with Lauder (1987) who found that beaches in the Pelorus Sound contained coarser material than adjacent offshore areas. Secchi disc results showed moderate visibility (K=0.52). This area has a large impact aesthetically on the area as natural contours of the land have not been adhered to when logging boundaries were made and the bare ground of this catchment contrasts greatly with surrounding bush. This is highlighted in Plate 4.7.

Plate 4.5: Platform collapse and deposition of slash material in gullies.

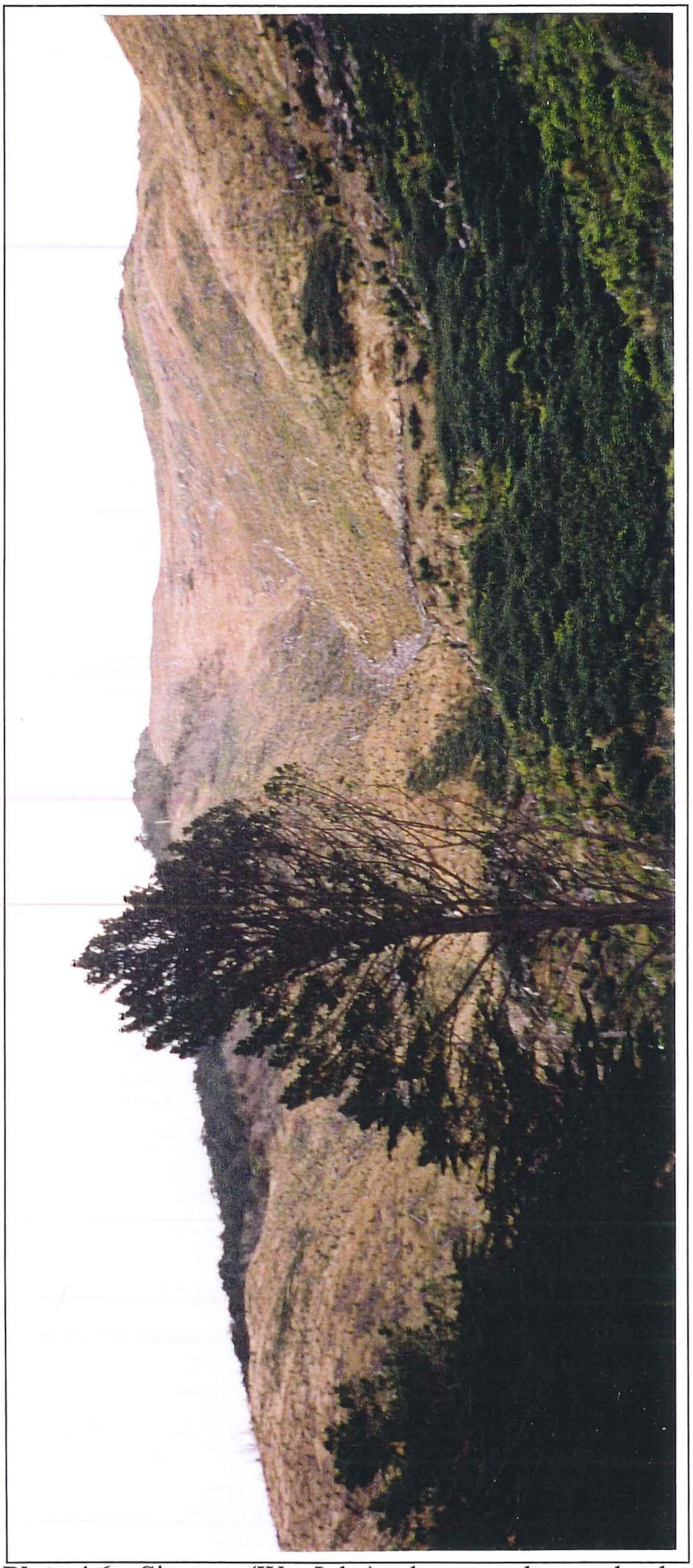


Plate 4.6: Site two (Wet Inlet) a large catchment that has recently been replated in P. radiata.

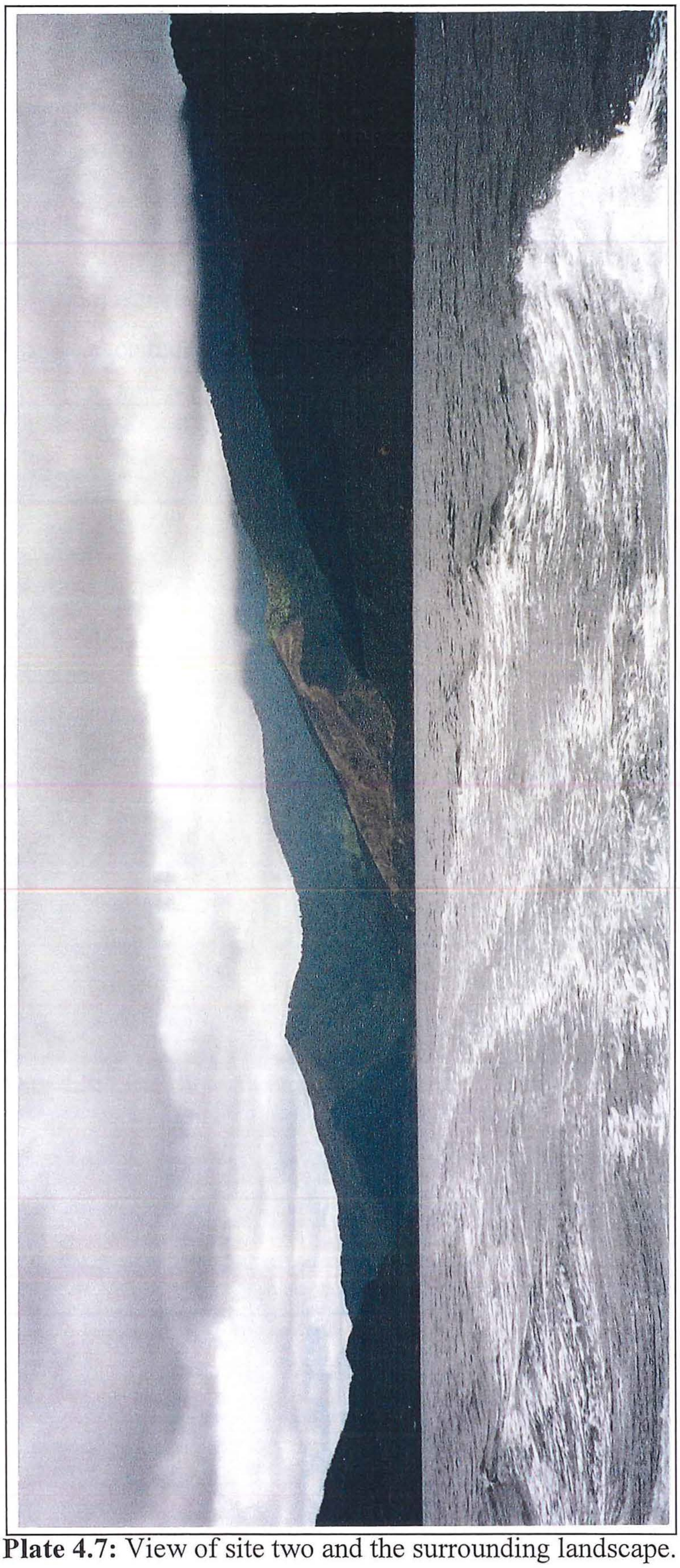


Plate 4.7: View of site two and the surrounding landscape.

Site three: North Tawero Point -This site is farmed land. Plate 4.8 shows a number of slips present reflecting the difficult nature of farmland on the steep Marlborough Sounds hill slopes. This site is a relatively high energy one compared to other sites due to its proximity to Cook Strait and alignment to a large fetch. This beach is well armoured with coarse material to protect the adjacent land. At this site no dredge sample could be obtained due to the coarseness of the bay floor. The secchi disc results indicated a K value of 0.5, hence moderate visibility.

Plate 4.8: Site three showing landslips and a well armoured coast.

Site four: Jacobs Bay - This site was chosen to show the contrast between the other land uses and native bush (Plate 4.9). Dredge samples at this site had a wide range of grain sizes but were free of clays and had very little silts. Secchi readings indicated moderate visibility (K=0.52).

Plate 4.9: Site 4 (Jacobs Bay) showing native bush catchment type.

Site five: Four Fathom Bay - This catchment has been farmland in the past but within the last five years has been converted into forestry (Plate 4.10). This site is similar to site two but contains deeper soils. The deep soils may have been the contributor to high sediment content in the dredge samples. Silt content in this bay was 51.5% of the total sample. Clay was also present to a lesser extent. Secchi readings revealed good water visibility indicating that the fine material transport to the bay is settling quickly and not being agitated by wave and tide action (K=0.4).

Plate 4.10: Site 5 (Four Fathom Bay) an example of farmland converted to forestry.

Site six: Four Fathom Bay - This area has a 25 year old stand of P. radiata with a small riparian strip present at the head of the embayment (Plate 4.11). The riparian strip contains a number of exotic pines that have either been planted there or have regenerated as wilding pines. The dredge samples in this bay were coarse with only 23% of fine sediment. Secchi results indicated moderate visibility (K=0.5).

Plate 4.11: Site six (Four Fathom Bay) - mature exotic forest.

Site seven: North Putanui Point - This site is currently being logged and has been for the past two years. The block has a small riparian strip that although is aiding in reducing the sediment loads transported to the coast, has been breached in numerous places (Plate 4.12). Dredge sample data revealed mainly sand and some silts and clays were present on the bay floor. Secchi disc measurements indicated low visibility suggesting that much sediment was in suspension and had not settled to the bay floor (K=0.55). Plate 4.13 shows that visually this catchment is an eyesore. No effort has been made to replant areas already logged. In Plate 4.14 a residential development can be seen which would have both visual, noise and dust effects. Adjacent use can also be identified in Plate 4.15, where mussel farming is in progress.

Plate 4.12: North of Putanui Point, showing breaching of the Riparian Strip.

Plate 4.13: The visual effects of forestry on the landscape.

Plate 4.14: Conflict of use between forestry and residential development.

Plate 4.15: Shows forestry and the adjacent water use of mussel farming.

Site eight: Mahau Sound - This site was cleared approximately 30 years ago and can be identified in Plate 4.16. Following clearance a large rainstorm resulted in sediment movement both suspended in water and mudflows. This led to the adjacent bay infilling. The dredge samples at this site contained 100% sand, silt and clay and visibility was very poor (K=0.7 nearshore and 0.8 offshore).

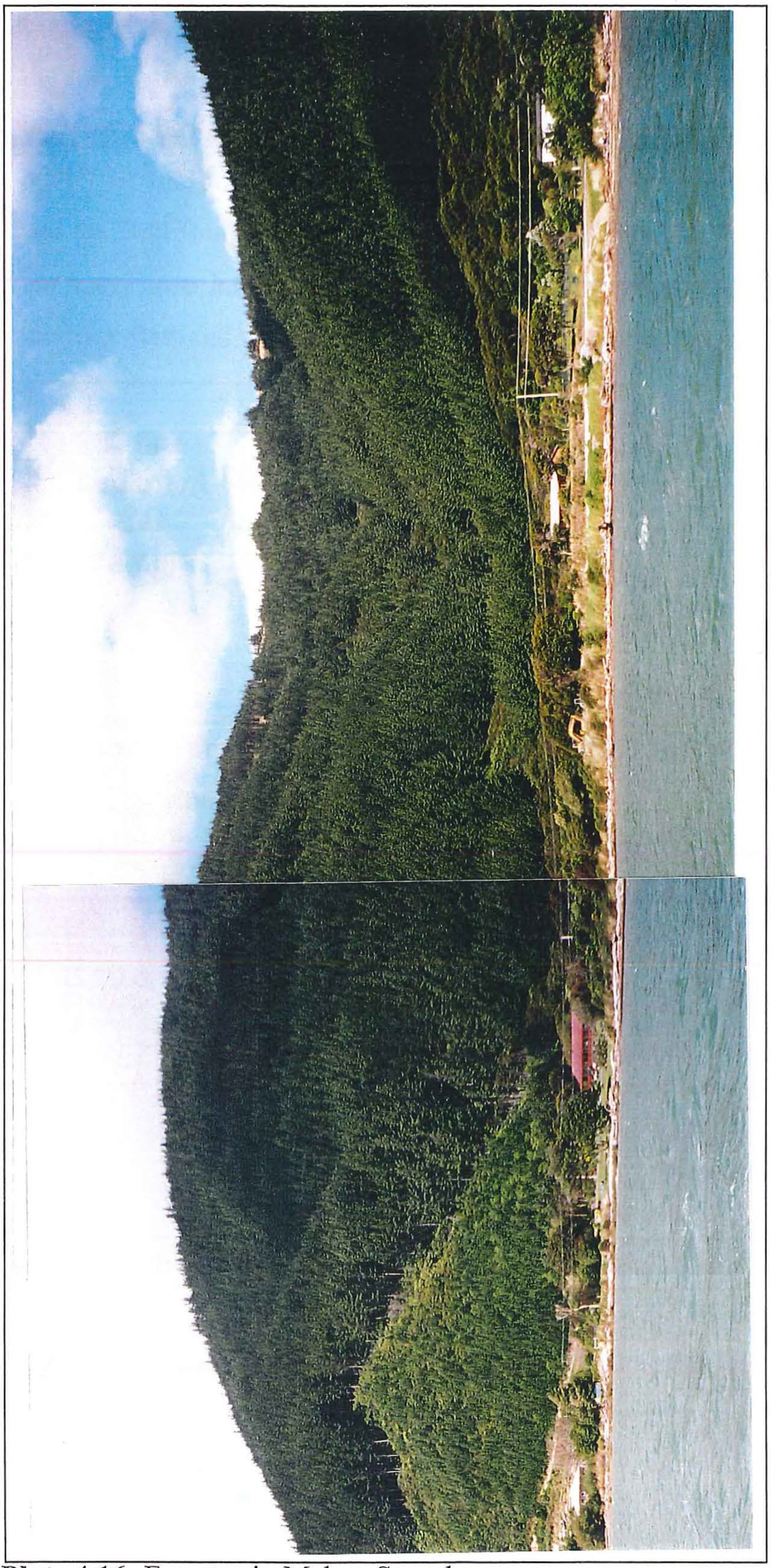


Plate 4.16: Forestry in Mahau Sound

Figures 4.9, 4.10, 4.11 show that the closer the catchment is to the Pelorus River mouth, the higher the percentage of fine sediment on the sea floor and the lower the visibility, both 30 and 50 metres from shore. The Pelorus River has a catchment area of some 89069 ha and originates from the Bryant and Richmond Ranges to the west and south and the Bull Range to the north. Most of the catchment is covered in indigenous forest but many areas have been planted in exotic pine recently. Farming is also undertaken in the river flats and terraces of the Pelorus catchment.

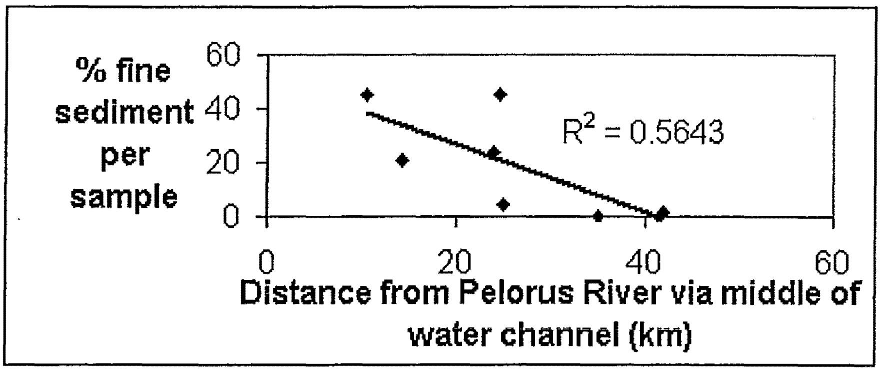


Figure 4.9: Percentage of fine sediment on the sea floor in relation to the Pelorus River.

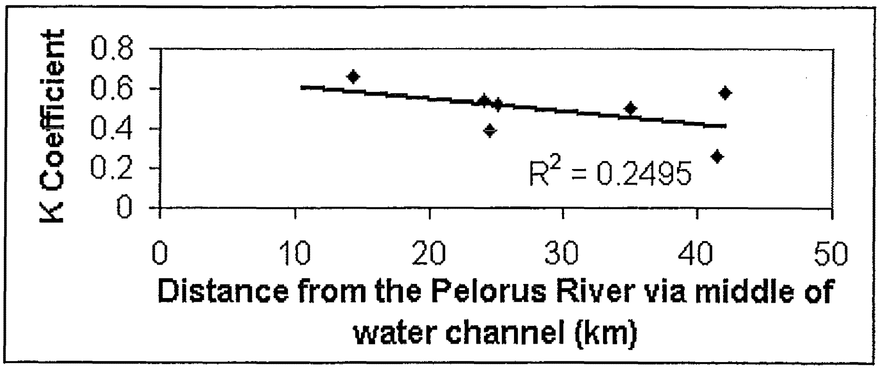


Figure 4.10: Secchi disc recordings 30 metres from shore.

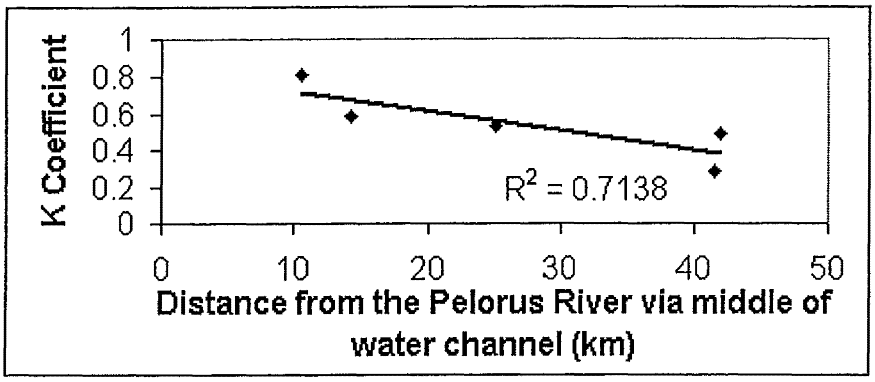


Figure 4.11: Secchi disc recordings 50 metres from shore

Adjacent to the Pelorus River mouth is the Kaituna River mouth, which also transports sediment to the Sound. This river drains the eastern end of the Richmond Range and the western flanks of the Kaituna-Tuamarina hill country and has a catchment area of 17400 ha (Sutherland *et al.* 1992). The catchment is predominantly pastoral farming although exotic forests have been established in some areas. Landslides in the area are numerous and superficial slip erosion is widespread leading to high sediment loads in the river.

The relationships between the Secchi Disc recording and the Pelorus River did not explain the variance sufficiently and data points are too few to draw reliable conclusions. However, 50m out from shore secchi disc results had a much stronger relationship of 0.84 and explained variance of 0.71. This suggests that the Pelorus River was contributing to sediment in suspension in the channels. However, in the embayment, catchment use had more of an influence.

These findings are consistent with those of Vincent (*et al.* 1989), who found that water became less turbid towards the open sea. Their secchi depth recordings increased three fold between the inner (Mahau Sound) and middle (Yncyca Bay) Sounds. It is also consistent with findings from Carter (1976), who found that this trend in increasing suspended sediment concentrations towards the Sounds head was due to the influence of the Pelorus and Kaituna Rivers and because of resuspension of bottom sediment by strong tidal currents.

Carter (1976) also found that suspended sediment concentrations decrease along Pelorus Sound until the entrance where suspended sediment levels increase as a result of sediment brought in from Cook Strait with the flood tide and with the greater production of biogenic suspended sediment. Thus forming a double-ended sediment trap.

Figure 4.12 shows the relationship between catchment use and both fine sediment concentration on the bay floor and water turbidity in the embayment. Results show that all stages of the forestry process contribute to high sediment concentration on the bay floor where as native forest and farmland contribute very little. Secchi recordings indicate low visibility during logging operations. However, this material settles quickly as shown in the recently logged data where sediment concentration on the bay floor is high and the visibility is also high. Recently planted areas have high amounts of sediment concentrations on the bay floor, presumably due to ground disturbance for land clearance. As indicated earlier, farmland as a catchment use is expected to have higher sediment concentrations on the bay floor than what was found in this study.

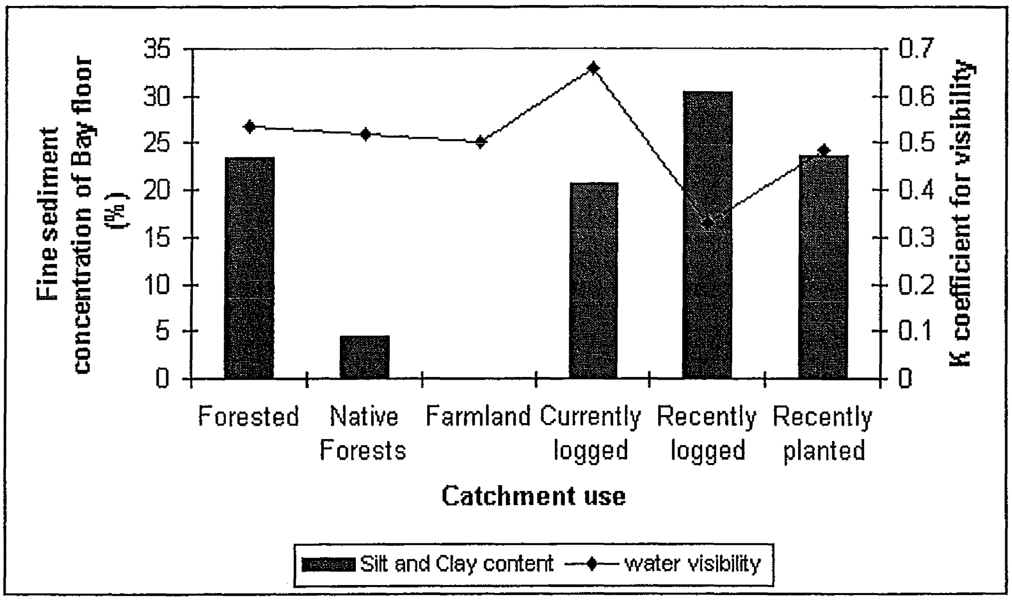


Figure 4.12: Fine sediment concentration and water visibility adjacent to different catchment uses.

Results may also be influenced by the fact that both the Mahau Sound site and the currently logged site (which were expected to have high sediment values) were closest to the Pelorus River, while different land uses such as native bush and farming were in the outer Sounds. Fine sediment quantities in the coastal zone may also be influenced by the wave environment in the bay. Generally the outer Sound have a higher energy wave environment.

The amount of fine sediment in the bay is partly determined by wave characteristics. The Marlborough Sounds is characterised by short choppy waves which do not 'feel bottom' until close inshore. These low energy waves yield a narrow range of velocities acting on the shore and form a shore with a wide range of sediment sizes. Sediment transport is also controlled by the distance and direction of the plume of water and sediment derived from the land and the settling time in the water column (Lauder and Kirk, 1985).

Lauder and Kirk (1985) discuss the relative intensity of effects of sedimentation between sites. They suggest that this is controlled by;

a) the relationship between catchment size and the volume of the receiving water body,
b) the depth of the nearshore water body,
c) the foreshore gradient,
d) the configuration of beaches and bays.

These facets of sedimentation were not addressed in this study but may have influenced results and should be considered in future work.

4.7.3 Conclusions from this study

It can be concluded that in the Pelorus Sound land use is changing the face of the area, aesthetically, perhaps recreationally, and ecologically as monocultures replace natural bush. However, as far as forestry's effect on the coastal zone is concerned, effects though profound, are spasmodic and dependent on other environmental variables such as rainfall during land clearance for planting or logging, depth of soil and energy level of the coast.

This study on the effect of forestry on the coastal zone has showed that although visually forestry is having a massive effect on the Sounds, the long term effects of sedimentation and water turbidity in the coastal region is more likely to be contributed by the Pelorus River. This river carries 319,158 t/yr of sediment to the Sound and thus has the potential to influence sediment levels and visibility markedly. Decreasing some of the effects forestry has on the coastal zone must still be addressed as results indicate forestry practises are having an effect on sediment concentration on the bay floor. The following parts of this chapter address how catchments are managed and suggest how they could be managed to reduce the effects of forestry practise on both the coastal zone and the area in general.

4.8 Management

From 1968 land disturbance was controlled by a public notice (Section 34 notice, pursuant to the 1959 Amendment to the Soil Conservation and Rivers Control Act 1941). This act required landowners to get written consent from Council before burning or disturbing land was carried out. This notice was replaced in 1991 with the introduction of the Resource Management Act which now addresses the effects of land use activities (including land disturbance) through the planning process. Planning occurs through the following process (Figure 4.13).

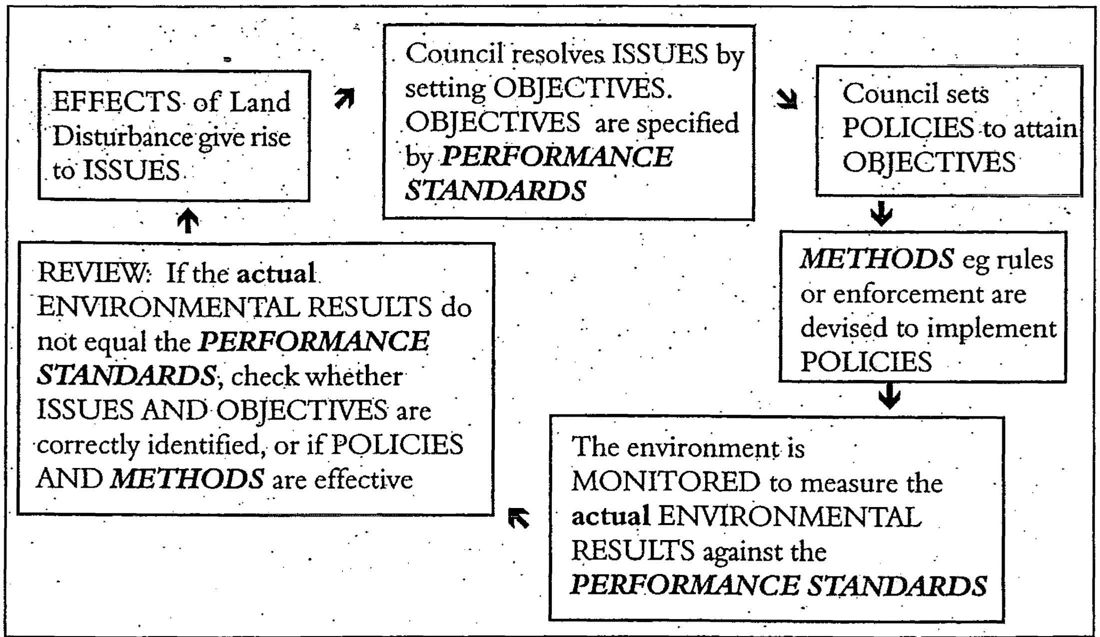


Figure 4.13: Process of resource protection (Marlborough District Council, 1994, P.9).

Under the Resource Management Act (1991), land uses can be termed either 'permitted' (allowed without consent), 'controlled' (permitted subject to application for a resource consent being granted), 'discretionary' (permitted subject to specified terms and conditions and may be declined by Councils), 'non-complying' (activities that contravene a rule in the plan and for which an application for a resource consent must be made) or 'prohibited' (these activities are specified in the plan). Both controlled and discretionary activities may require public notification and the hearing of any public submissions.

Commercial forestry can be a discretionary activity on better quality soils/land types or where landscape is seen as a significant consideration, and a permitted activity on poorer land such as Land Classes V, VI, and VII in the Land Use Capability System (as defined in the National Water and Soil Conservation Authority's Land Resource Database) (Ministry of Forestry, 1994). In the Marlborough Sounds forestry is a discretionary activity and consequently the Marlborough District Council must be consulted about plans for forest growing. Proposals need careful planning as financial assessment of harvesting, log transport and growing conditions are important aspects to evaluate feasibility. Difficult access areas in the Sounds can have very high logging and transport costs, and in these areas, growing high value logs is critical for profitability (Ministry of Forestry, 1995).

Another effective management tool is the New Zealand Forest Accord which was signed by New Zealand forestry enterprises and conservation groups to fulfil the following objectives;

- To define those areas where it is appropriate to establish plantation forestry
- To recognise that commercial plantation forests of either introduced or indigenous species are essential sources of perpetually renewable fibre and energy offering an alternative to the depletion of natural forests
- To support the production management and harvest of naturally occurring indigenous forests only where such activity is conducted on a sustainable basis. A 'sustainable basis' is considered to be a rate and method of tree extraction that doesn't exceed the replenishment so that the forest ecosystem in the area under consideration is maintained in perpetuity (The New Zealand Forest Accord – agreement paper, 1993, cited in Hedén and Borgström, 1999). This definition for 'sustainable basis' is not practical as this type of harvest would be uneconomical therefore in reality exotic forestry harvesting does not follow this guideline.

This accord promotes forestry as a desirable, renewable resource that can release pressure on indigenous forests and create products that are environmentally friendly and sustainable. This document has done more than anything else to alter the public perception of plantation forestry (Potton, 1994).

The New Zealand Forest Code of Practise (Visser and Smith, 1993) outlines how foresters should plan, manage, and carry out forestry operations in sustainable manner. This tool is a valuable guide for the forester and should be utilised in making most decisions in the forestry process. Visser and Smith (1993) outline the importance of valuing soil and water, culture, scenic values, recreation, science and ecology, forest health, site productivity, off-site impacts, safety and commerce. Use of the code in the environmental planning process is outlined in Figure 4.14.

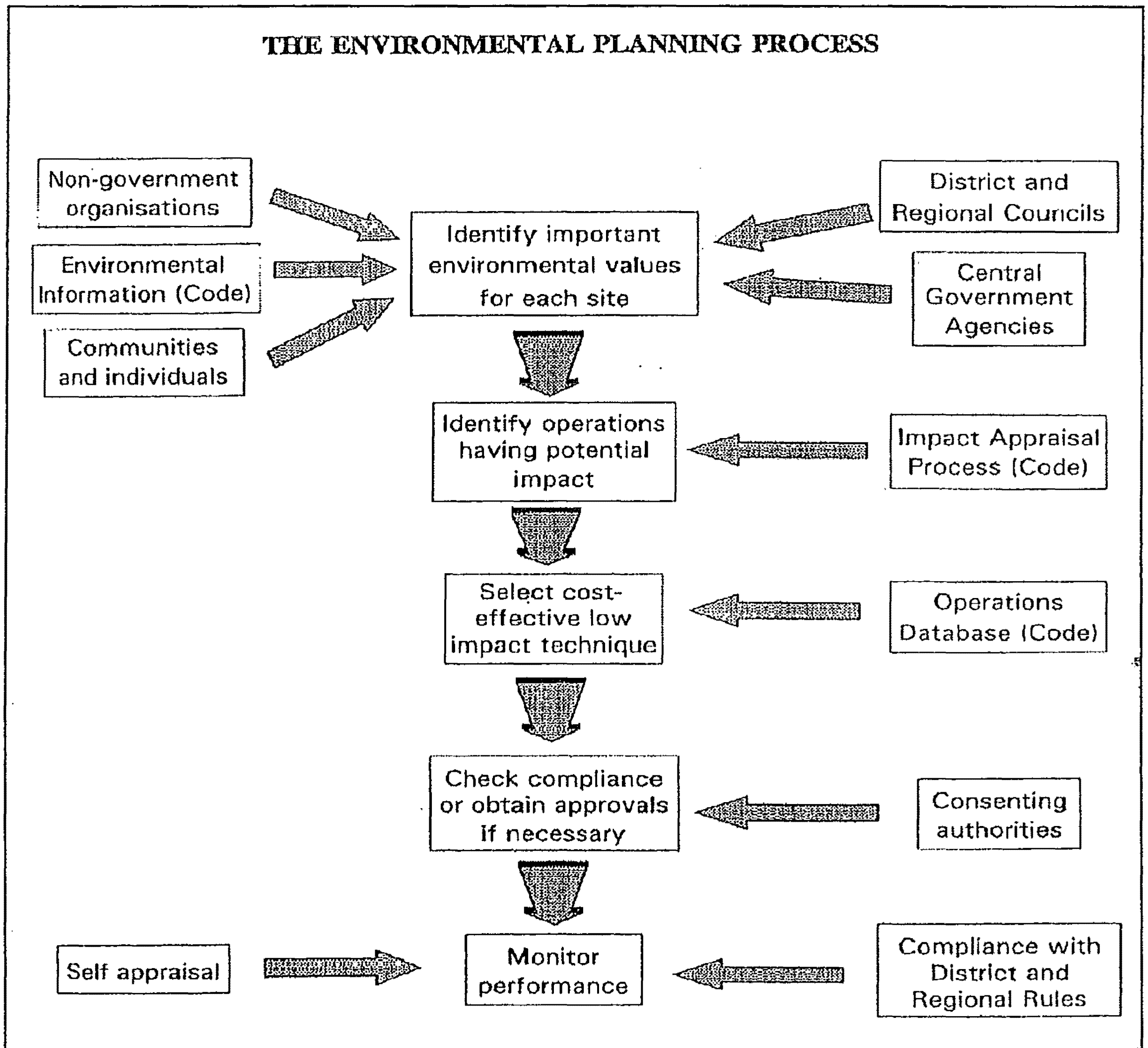


Figure 4.14: Use of the Forest Code of Practise in the environmental planning process (Visser and Smith, 1993, P.5).

Other important documents to consult include the Best Practises Applying to Resource Consent available from the Marlborough District Council as well as the Marlborough District Plan. Non-government organisations are also useful to approach to gain perspectives on important environmental values (for example, Maori interest groups, Fish and Game Councils).

Management of forestry in the Marlborough Sounds requires a plan to apply for consent and determine viability of production. The plan should include ecological, economic and cultural constraints. To complete the planning process, monitoring of operation performance specified in the plan should be undertaken.

4.8.1 Why management of catchments is important

The Marlborough Sounds region is particularly sensitive to land use changes because of its unique physical features (Laffan *et al.* 1985). The steep slopes dropping into the sea lead to even small catchments discharging directly into the sea.

The Marine Resource of the Marlborough Sounds has a wide variety of commercial and recreational uses. Uses include shellfish and salmon farming, tourist cruises, sailing, power-boating, commercial and recreational fishing, swimming, underwater diving, transport links between and in and out of Havelock and Picton for the transport of timber, cargo and people. For optimum and safe use of the marine environment the waterways must be free of pollution, effluent, and floating debris. To preserve this aquatic environment land activities must be carefully managed so as to reduce erosion, runoff and sedimentation.

4.8.2 Various management practises to reduce adverse effects on the environment

Forest cover is widely acknowledged as a stabilising influence on the soil but stability can be lost in production forests by site disturbances resulting from management practices. Although any impact of decreased water quality from suspended sediments may be only short term and dependant on forestry operations, the impact on sedimentation may be long term. Laffan (*et al.* 1985) found that management practises are most crucial on thick regoliths below 200m especially on thick saprolites. Greatest impact occurs when management practices penetrate or remove topsoils and expose underlying materials (for example, roading, firebreaks, tractor-logging tracks and cable skidding). Management practise that minimise disturbance include burnoff and scrub crushing operations during establishment and skyline, and helicopter-logging techniques (Laffan *et al.* 1995).

4.8.2.1 Site preparation

The Sounds area is known for fast growth of gorse, broom and other scrub weeds. It is important for this material to be moved before planting because thick vegetation is difficult to walk through for planting and excavating a planting hole. These species also compete for valuable nutrients and light with the planted trees, therefore hinder productivity. These weeds can be removed mechanically, by burning, or by aerial spraying.

Mechanical forms of removal (for example, roller crushing or slash raking) can be very erosive of the land. By removing rain intercepting foliage and removing valuable topsoil, sediment removal into the coastal zone will be evident. Dyck *et al.* (1989, cited in Maclaren, 1996) found that at age 17 years, tree volumes in areas that had been scraped declined by 258% relative to wind throws or heaps. The growth differences were attributed to nutrient depletion and moisture stress.

In the past burning has been the cheapest form of land clearance but this is no longer the case due to the requirements of firebreaks, staff and machinery (including helicopters). The ash is a quick-acting fertiliser at a crucial time of plant development so has excellent short-term benefits. However, burning can also trigger the germination of many intractable weeds and create a more severe weed problem. It also holds concerns for surrounding stands that have the potential to be damaged. This method of site clearance can increase the amount of nutrients in waterways and much can be lost off the land causing long term effects. It is important that burns are controlled and leave riparian vegetation. Good burnoff practises can be viewed in Plate 4.17.

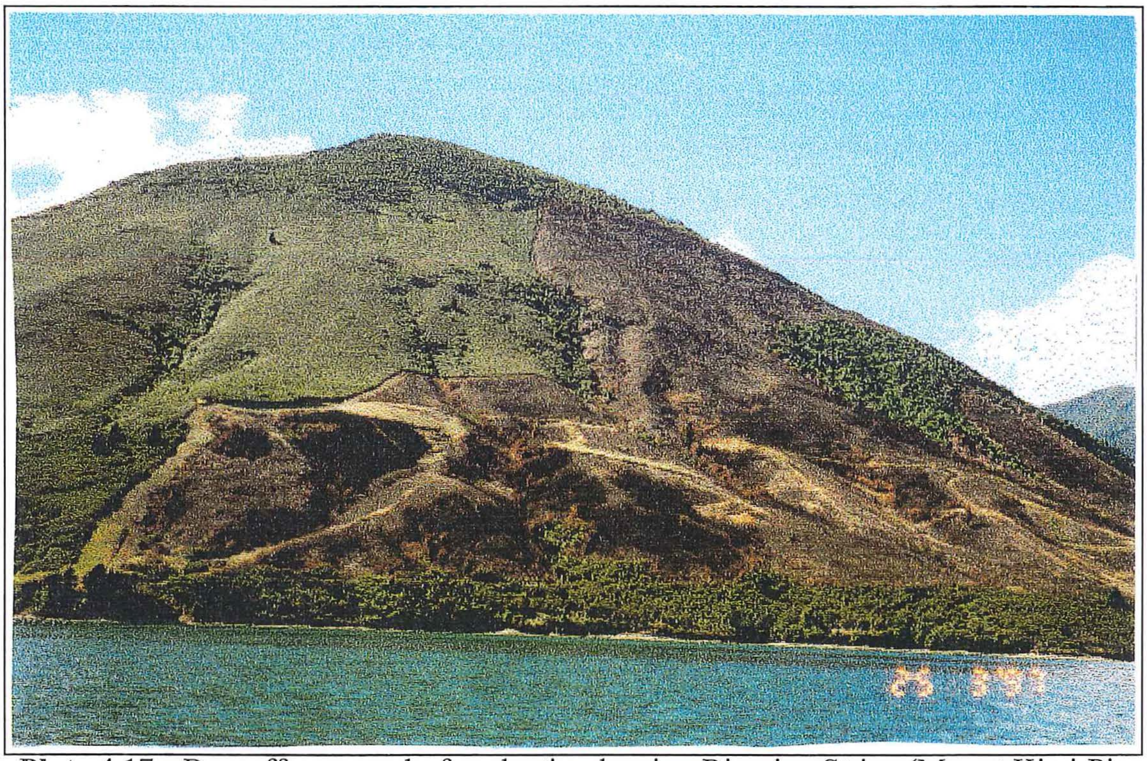


Plate 4.17: Burnoff area ready for planting leaving Riparian Strips (Mount Kiwi Pines Ltd).

Due to the Marlborough Sound's topography and poor roading networks, spraying weeds is a more viable option than working heavy machinery on the steep slopes or loosing soil nutrients from burning. This option is often condemned by environmentalists but if used correctly it can provide an environmentally friendly approach to site preparation (Maclaren, 1996). Spraying must not affect non-target species.

4.8.2.2 Roading

Sediment production studies have highlighted the importance of roads and contour tracks as major point sources of sediment (Fahey and Coker, 1989, 1992). Sediment losses from roads can be greatly reduced by careful planning, road construction, and rehabilitation. Location of roads away from streams and on slopes of generally less than 9% led to little increase in stream sediment loads in Idaho (Haupt and Kidd (1965) cited in Morgan and Graynoth 1978). After logging was completed soil loss from skid tracks and roads was restricted by digging cross ditches, establishing grass, and spreading wood debris across tracks and roads.

Roading on lower altitudes should be avoided and harvesting and vehicle movement should be restricted on wet days. These practices result from studies (Fahey and Coker, 1992) showing that soils at lower altitudes are more erodable due to the high levels of deep weathering. Coker (*et al.* 1993) found that trucking during rainfall could increase sediment levels by 16 times compared to non-trafficked roads under the same rainfall regime.

Roading has a long-term effect on suspended sediment levels in streams, because, unlike scrub raking or linedozing, there is no vegetative cover to minimise effects of site disturbance. Roading does however have times when surface erosion is highest. When roading is first constructed erosion is high but decreases as the road surface stabilises (Coker, 1994).

4.8.2.3 Reducing landslides

During logging operations, the steep Marlborough Sound hill slopes are susceptible to landslides. Plate 4.18 shows a coastal embankment that has failed. Water from springs behind the slide had been diverted over this face by slash build up, rather than down the tree gully to the right. Historic evidence of landslides in the area can be seen in different aged vegetation stands adjacent to each other. It can also be seen in infra-red photography (R.D. Sutherland, cited in Lauder and Kirk, 1985, P.119). To reduce mass wasting failure prone sites must be identified, steep slopes must not be overloaded and careful drainage is needed.

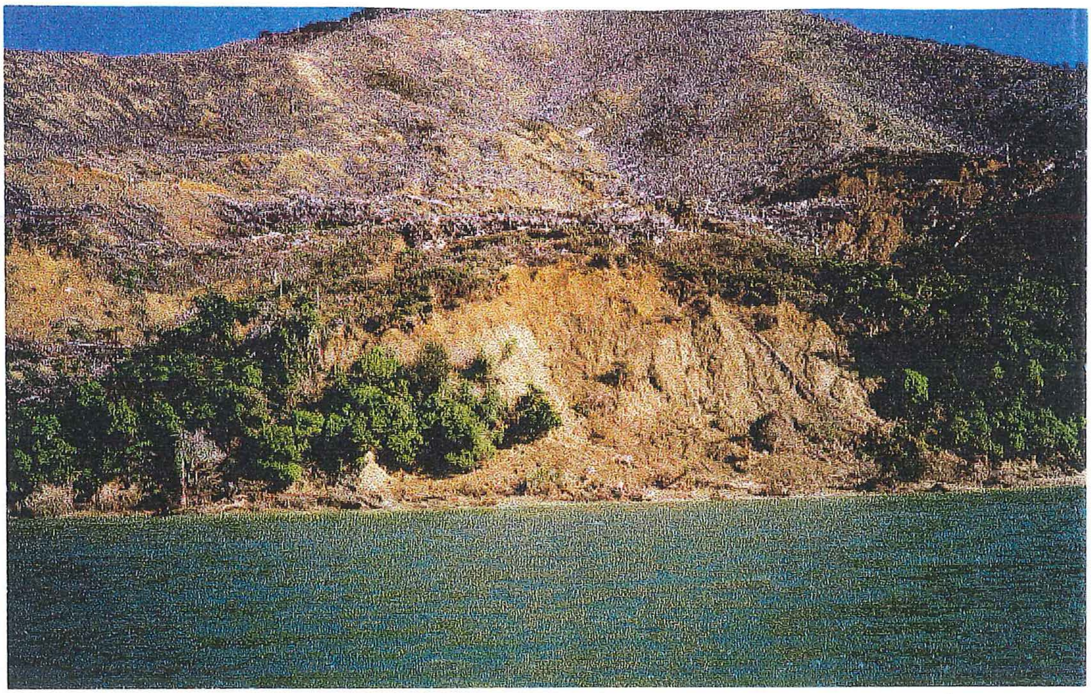


Plate 4.18: Landslide caused by poor drainage of runoff.

4.8.2.4 Use of a Riparian Strip

Riparian Strips are an important physical feature in the Sounds as they are involved in such processes as shading the surface of water, and the ecotone processes of filtering sediment and nutrients. These strips maintain the biodiversity of indigenous terrestrial and aquatic ecosystems, and the quality of the water. They provide natural corridors for the movement of wildlife between larger habitat areas and provide a refuge for fauna to escape vegetation disturbance on adjoining production land (Royal Forest and Bird Protection Society, 1995).

Part II of the Resource Management Act, describing the principles of the Act, is relevant to the integrated management of land and water. In accordance with the purpose of the Act, riparian margins must be managed sustainably.

Haupt and Kidd (1965) cited in Morgan and Graynoth (1978), recommend buffer strips of riparian vegetation (with a width of at least 9m) retard overland sediment flows. The buffer strip should have extra cross ditches and the addition of slash to the strip in critical areas. Riparian strips function as a 'sponge', greatly reducing nutrients and sediment runoff into streams.

Rogers, (1996) found that the New Zealand public have a very strong preference for visual buffers. Rogers (1996) suggests that where forests are in highly visible areas and where the impact of forestry operations may impact on visual amenity values, where possible, a buffer of trees be left standing to screen the operations behind.

Riparian strips are costly in that the land is unused for production, extra firebreaks are needed, and it is difficult to harvest around and over them. These strips are critical for only a short period of the forestry cycle and may have little effect on water quality in some areas where point sources originating from poor drainage control on roads, tracks or loadings uphill, and exit into the waterways before they encounter the riparian vegetation (Visser, 1995a, cited in, Maclaren, 1996). This highlights the necessity for a range of conservation practises to be employed in a forested area.

4.8.2.5 Method of logging

Aerial logging with the use of helicopters causes little erosion. Skyline methods of logging where the logs are suspended above the ground create very little disturbance and reduce the need for roads. Less roading decreases suspended sediment runoff and is aesthetically more pleasing. High-lead methods, where logs are dragged by cable to a central winch, disturb the soil surface over a wide area. Tractor and skidder logging, which leave a network of tracks over the hillside, cause the greatest erosion since more of the subsoil is disturbed than by other methods. Harvesting plans are required before the commencement of planting, as forward thinking is important and often less costly long term, in reducing the environmental effects of forestry.

4.8.2.6 Stagger harvesting times

Farnham Forest was influenced by serious landsliding as it was harvested in a 'one hit' operation which involved tree felling over the whole slope. To combat this problem, O'Loughlan, (1985) suggested logging of upper slopes only in the initial operation and logging the remaining lower slopes after 4-5 years so as to enable the upper slopes to develop a stabilising vegetation cover. This technique however would substantially increase the cost of logging and would require careful extraction to remove timber from lower slopes up through regenerating forest.

4.8.2.7 Transport networks

The roading network in the Sounds is not good therefore it is proposed that a lot of wood will be transported from the hillside by barge to the nearest port (either Picton or Havelock). Plates 4.19 and 4.20 show loading of a barge in the Sounds by aerial cable and front loader. If barging is proposed to be the method of transportation of the product, barge sites must have a low tidal range and relatively deep-water nearshore so as not to run aground, therefore these qualities must be present in proposed sites. Coastal loading sites may also be necessary if vehicle loading is proposed. Log rafting (where bundles of logs are tied together and float in the water) is not permitted due to danger to water quality standards and nearby marine farms (Ministry of Forestry, 1994).

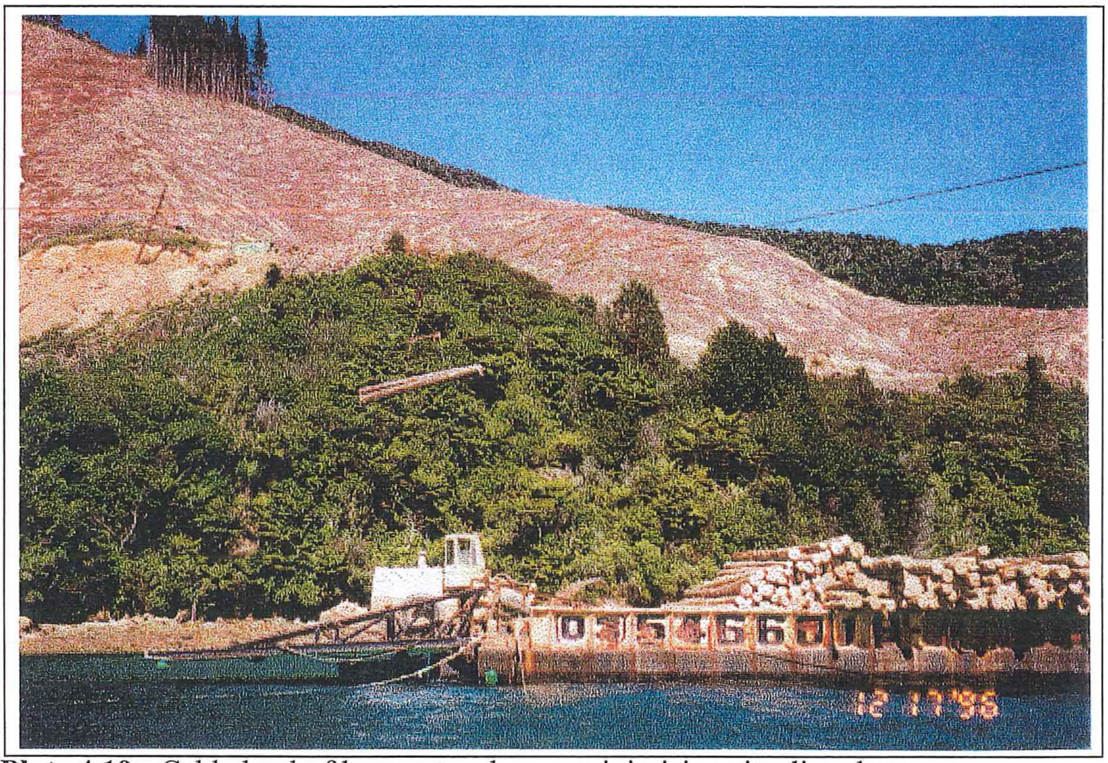


Plate 4.19: Cable haul of logs onto a barge, minimising site disturbance.

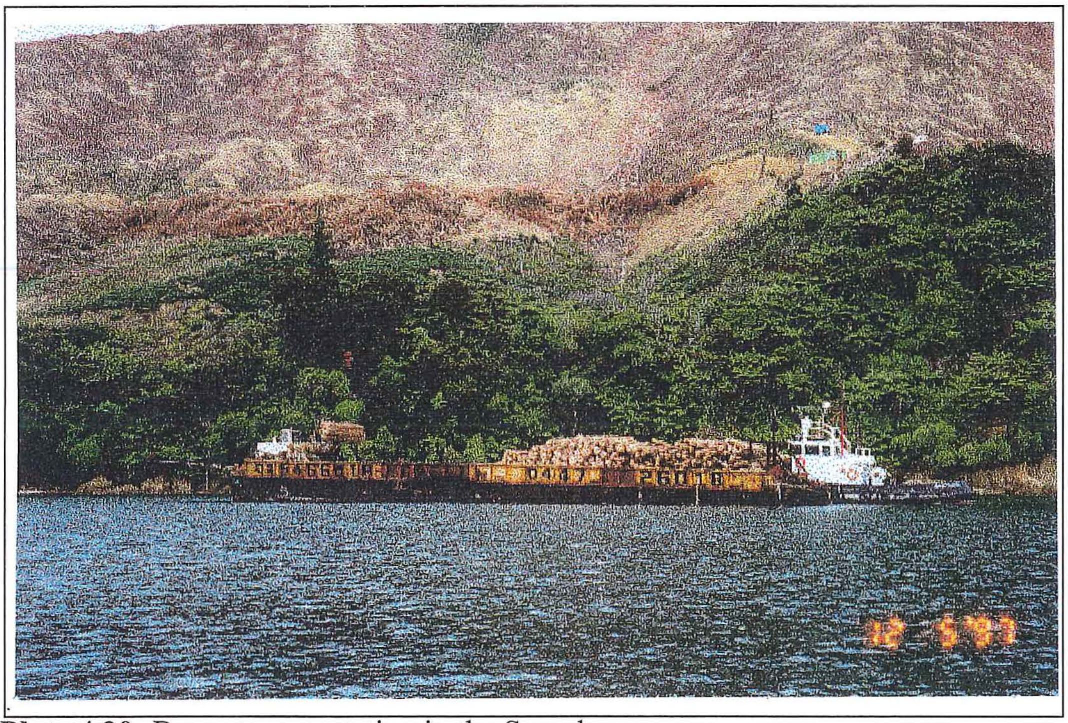


Plate 4.20: Barge transportation in the Sounds.

A problem identified with trucking is the amount of trips needed to service such a large yielding product leading to increases in noise, dust, highway congestion and road maintenance (Maclaren, 1996). Thus barging can carry more product, making less trips, minimising impacts on other uses of the area.

4.8.2.8 Aesthetics

There is a need to identify areas that are visible from neighbouring properties or public access points. These areas need to be managed to a satisfactory level of disturbance, which can be obtained from qualitative surveys of stakeholders or parties affected. Landscape architects may be employed to formulate proposals that are accepted by all parties (Maclaren, 1996).

Visser and Smith (1993) have suggested methods to reduce visual impacts of forestry. Suggestions include that there may be a need for revegetation of visible cut and fill surfaces to reduce colour and line contrasts from exposed subsoils. Firebreaks can be planted in lucerne to provide green fire breaks and control noxious weeds. During harvesting, logging in keeping with natural landscape features will reduce the impact on the visual landscape.

4.9 Summary of forestry as a land use in the Marlborough Sounds

This chapter has discussed the forestry resource in the Marlborough Sounds and has suggested some effects of this resource use on the area. Over much of the growing cycle forestry will be beneficial for soil stability and water quality due to the strong root system of Pinus radiata (O'Loughlin, 1984, 1985). However, during harvesting operations, site preparation and making access tracks, varying impacts on adjacent waterways can result. It is at these times that special management practises must be carried out. This chapter has found that the landuse of forestry has changed the landscape of the Marlborough Sounds markedly. The reversion of farming or regenerating scrub to forestry has visually had an effect on the landscape of the Sounds.

Forestry as a landuse is sustainable and is suitable to the Marlborough Sounds environment. It has infrastructure in place such as export ports and transport networks via sea to accommodate the product. New Zealand's nearest export market; the Pacific Rim has the fastest growing demand for wood products in the world (Ministry of Forestry, 1994). Thus, the future for wood export demands is economically secure.

However, forestry can be detrimental to other resources in the Sounds. Mussel farming, recreational use, and effect on both aquatic and terrestrial flora and fauna are identified resources that can be effected by forestry. The main effects from forestry on other resources in the Sounds include an increase in fine sediment levels both suspended in the water column or deposited in adjacent bays and an increase in slash debris that can be deposited in the coastal area. The coastal zone is an important resource in itself as it is heavily utilised. It was identified that forestry does influence the coastal zone but other factors are also contributing to changing sediment levels at the coast (for example the Pelorus and Kaituna Rivers).

Forestry is important to the prosperity of Marlborough but it should not be detrimental to other uses of the Sounds such as recreation and marine farming. As stated by the Ministry of Agriculture and Forestry (1976, P.18),

> 'The planning problem is the accommodation of the different land and water uses ensuring that natural, cultural, landscape and recreational values are enhanced and the welfare of the population provided for in proper recognition of national, regional and local needs'.

Management practises that reduce the effect of forestry on the coast were identified. These practises include spraying rather than manual removal of scrub during site preparation, reducing the amounts of on site roading, using an Riparian buffer, reducing ground disturbance when logging, staggering harvesting times, barging timber product to port and reducing the visual impacts through revegetation and logging in line with natural landscape features.

Every landscape carries within itself the potential to evolve new relationships but much of this potential lies in management or control. Humans can steer the processes in a direction more beneficial to themselves (Anstey, 1982). The aim of management and planning in the Marlborough Sounds is to form a situation where all current uses are carried out without hindrance from others. Forestry is a human-imposed alteration made for social gain, but the advantage to society may be realised only in the future and away from the affected area. The challenge for the forester is to protect site values while accepting some alteration as social necessity (Anstey *et al.* 1982).

Chapter Three and Four have discussed the resources of forestry and ferries in the context of the changing landscape of the Marlborough Sounds. Chapter five will discuss the changing landscapes of the Marlborough Sounds through resource utilisation in more general terms.

CHAPTER FIVE

Resource Use and Landscape change in the Marlborough Sounds

Resource use – changing the landscape of the Marlborough Sounds

Τα παντα ρει

(Everything is in a state of flux.)

- Heraclitus, pre-Socratic Greek philosopher

5.1 Preamble

Many would describe the Marlborough Sounds landscape and associated seascapes as special. They exhibit strong local character made interesting with its varied topography and vitality of the land/sea interface. Marlborough has a diverse range of assets, ecological, social and economic. Many of these assets have come about through the development of resources, which are plentiful in the diverse geography of Marlborough as it forms a variety of landscapes and habitats. The variety of growing conditions, through the combination of soil, climate and water availability in Marlborough has formed the current landscape mosaic. This chapter discusses the resource uses of the Marlborough Sounds and how they came to be. Firstly a brief overview is given of the literature and thought on resource depletion and environmental change over the years.

5.2 Changing perspectives on human's use of the environment

The history of thought on environments and how they are utilised has been long. Intelligent humans have always valued their environments for the species and features, which came to have cultural, economic and spiritual significance (hence resource value). Resources and their uses have changed over the centuries as resources depend on knowledge and technology. However in most of these civilisations, people have in the past rarely valued nature for nature's sake (Ministry of Environment, 1997). Rather it has been more common to value the environment for what it holds in resource value rather than for its character.

Many writers have studied how humans utilise resources and change the landscape in doing so. They often write from a conservation perspective on how destructive, development of the landscape can be. The following paragraphs relay a short overview of the literature on resource use and how the perceptions of academics have changed over time.

George Perkins Marsh the Author of "Man and Nature" (1864), was one of the first to explore the concept of conserving resources for future generations. His first book was titled "Man the Disturber of Nature's Harmonies". There was discussion on the title as people argued that humans acted in harmony with nature, in harmony with its laws and humans are a part of nature. Marsh argued that humans are not part of nature and their actions are not controlled by the laws of nature. His book was written to illustrate the fact that "man, so far from being…a soul-less, will-less automaton is a free moral agent working independently of nature" (Pg. xxiv).

Marsh had amazing foresight for his time and although his view was inconsistent with others of his era, he is considered to be one of the forefathers of the conservation movement. Marsh was of the view that "Man has too long forgotten that the earth was given to him for usufruct alone, not for consumption, still less for profligate waste". The undertones of what is now coined sustainibility was a concept conceived by academics last century but has only been developed in the last 30 years. Unfortunately such thoughts were not considered by policy makers of the time or users of resources, therefore over a century later we are only just starting to take on board Marsh's advice of sustainably using resources.

Nearly a century later in 1956 'Mans role in changing the face of the earth' (edited by Thomas) was published. This text focused on what has been and is happening on the earth's surface as a result of humans having been on it for a long time, increasing in numbers and skills unevenly, at different places and times (Fejos, 1956). Most of the concepts in this book suggest that there is little hope for people on this earth as we have limited natural resources and our attempt at finding new and more intensive uses for the raw materials of nature have been fruitless. Contributors to this book also recognised the link between depletion of natural resources and humans increasing desire for consumption.

Carson (1963) contributed the book 'Silent Spring' to the literature. This book suggested an ecological approach to peoples relationship with nature. It focuses on humans use of pesticides and herbicides on the environment, highlighting Carson's biology background. This book maintained past views that humans are 'ruining and destroying their own habitat' (Carson, 1963, P.xxii).

In the early 1980's authors such as Humphrey and Buttel (1982) were linking economics to environmental degradation and were focusing on issues such as population growth and the limits to that growth in relation to famine and energy consumption. There was a shift during this time from the relationship between people and their environment recognised in phrases such as 'mans tenure on earth', 'mans effects or modifications on the environment' to a new term called environmentalism. Focus was not only weighted on the interaction with people and their environment but also on people's culture and how environmental degradation is a social issue.

Simmons books (1989, 1991) adopt an ecological-functional point of view and focused on the energy flow through ecosystems, primarily the ecology of people and their impact on the environment. Simmons book, 'Earth, Air and Water' published in 1991 focused on the concept of sustainable resource use that was already in the forefront of scientific thought building up to the Rio Earth Summit (1992).

Goudie (1994) addresses a number of contemporary environmental concerns for example, the use of aerosols and the carbon dioxide problem and interconnects the environmental uses with degradation. The concept of human impact on the environment is also studied by Goudie and Viles, (1997). These writers have provided a start point of understanding on an international scale of environmental change due to human resource gathering. The next section discusses resources in the context of the Marlborough Sounds.

5.3 Resources in the Sounds

Resources are defined by Zimmermann *et al.* (1972, P.8-9) as a combination of the following definitions;

1. That upon which one relies for aid, support or supply.
2. Means to attain given ends.
3. The capacity to take advantage of opportunities or to extricate oneself from difficulties...

The prefix *re* meaning 'again' suggests dependability through time as indicated in the term *relies* in definition number one. A person may have many sources of income but a nation has resources'.

'Resources are not, they become' (Zimmermann, *et al.*, 1972, P.556). Resources only have meaning in combination with human knowledge, culture and skills in relation to a specific resource (Heijman, 1991). For example, oil was not a resource in the seventeenth century, while today, it is of vital importance to the world economy. To a large extent resources are humans own creation (Zimmermann *et al.* 1972). Mitchell, (1940 cited in Zimmermann *et al.* 1972) states that knowledge is the mother of all resources as not only do we require knowledge to realise resources and to acquire them but the mind is also a resource in itself.

Natural resources include water (including rivers, lakes, coastal, and geothermal areas), land (including soils forest and farmland), air and minerals (including coal and oil). Human existence depends on these resources, therefore the management of them is of upmost importance, especially as resources can run out. Bennett (1976 cited in Simmons, 1989) examines the complex linkages and feedbacks of human use of the earth (Figure 5.1). As technology evolves, greater net energy surplus is produced, hence more material success and more environmental change.

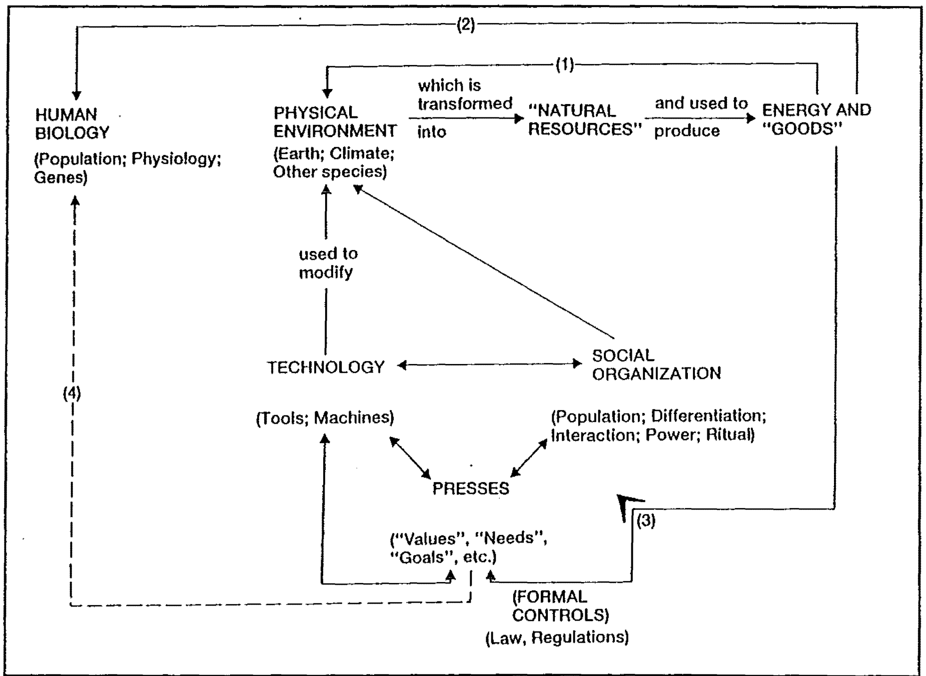


Figure 5.1: The complex inter-relationships and linkages between humans and their environment and resources (Bennett 1976, cited in Simmons, 1989).

The coast and its adjacent areas contain resources because they are perceived to be valuable. These resources change over time, as perception changes. 150 years ago, the dense native forest of the Marlborough Sounds was regarded as a resource for its wood product but sometimes a hindrance as cleared land was perceived to be a higher resource so farming could take place. Today, this perception has changed as farming is becoming increasingly unprofitable and people's views have shifted to acknowledge the resource of native forests for tourism, future generations, biodiversity and aesthetics.

Figure 5.2 represents elements affecting resource perception. In the past resources have been described to be the intersection of the subsets of economical viability, social desirability and technological possibility. However it is important that a resource is also environmentally possible. The intersections of these criteria show the resource (Figure 5.2). If the sets change, so does the resource. All criteria must be present for a resource to be present. For examples sake, the utilisation of the Marlborough Sounds for viticulture may be socially desirable and this resource use would be a continuum of other areas of Marlborough. It is environmentally possible, due to the soil type and rainfall and the steep slopes could be terraced for cultivation. The Marlborough Region also has the technology to grow grapes productively. However this option is not likely to be economically viable as planting, maintenance and harvesting costs on the steep slopes would be high and transport costs to processing plants would be costly due to the need for both sea and land transport. Therefore, viticulture is not a resource in the Marlborough Sounds as it is economically unproductive.

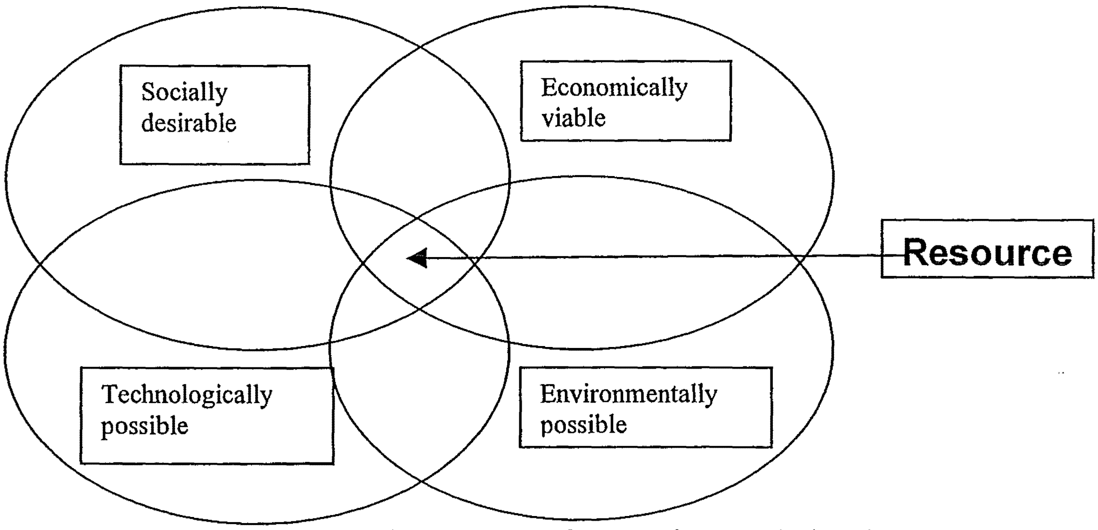


Figure 5.2: Resources are the outcome of perceptions such that they are seen as socially desirable economically viable, and technologically and environmentally possible.

'Man is the most dynamic agent of production and the beneficiary of the entire process of resource development and utilisation' (Zimmermann *et al.* 1972, P.87). Some assume that humans do not willingly spoil their environment, instead, cultural changes represent improvements in the landscape, reflecting a better adaptation of nature to humans needs (Zimmermann *et al.*, 1972). However in most cases development is a purposeful action devoid of thoughts of consequences. As humans evolve over time there is an increase in knowledge and society becomes more complex. This leads to an increased probability of misdirected effort due to lack of comprehension in decision making. The environment then suffers due to peoples refusal to reconcile properly the conflicting interests through opposing groups and between the present and the future (Zimmermann *et al.*, 1972). In the past the Marlborough Sounds has been developed with little thought of consequences and this has led to environmental degradation in some areas, especially soil fertility loss.

Now that resources have been defined and discussed, the next section will identify resource use in the Marlborough Sounds and the effect of this use on the landscape.

5.4 The face of the Marlborough Sounds – how it came to be

'Landscape' is not defined in any New Zealand legislation but has a long-established definition from the landscape architecture profession which states that 'the landscape reflects the cumulative effects of physical and cultural processes' (Royal Forest and Bird Protection Society of New Zealand, 1995). This is true for the landscape of the Marlborough Sounds. The landscape has formed due to environmental constraints and opportunities, as well as cultural influences such as perception, technology and knowledge of resource and management of the area.

The landscape of the Marlborough Sounds has undergone approximately six changes over the last two centuries. Change has occurred as resources have been realised and then utilised. The first landscape was pre European when most of the native forest was intact with a few clearings for subsidence farming and walking tracks that were often located on ridges. At this time the waterways were used for both fishing and shellfish gathering and boat use was limited to canoes.

Once European occupancy of the Sounds began in the mid 1800's changes in the landscape became more frequent and at larger scales. The first landscape change with the introduction of the new settlers, was the clearance of indigenous forest. Trees were felled to clear the land for housing and to obtain the raw wood product for settlers both in the Sounds and other areas in the country. At this time water use in the Sounds had increased with commercial whalers based in Tory Channel and Port Underwood, and larger ships bringing supplies to Picton.

The third landscape of the Marlborough Sounds was the utilisation of the land for grazing. Once the native bush was felled, the land was burnt off and farming cattle and sheep became the major source of income in the Sounds. This landuse was subsequently unprofitable as the meat and wool prices decreased and the moist weather made farms revert quickly to regenerating scrub. The landscape changed over time to a fourth stage as the Sounds became more easily accessible by roading and boat and thus more private dwellings and tourist areas were built. It was at about this time that water use increased with an increase in privately owned boats and a number of large ships making regular crossing from Wellington to the Sounds. The fifth landscape of the Marlborough Sounds is large areas of reverted farmland covered in scrub and native bush regrowth. In some areas this is still the landscape today.

The present Sounds landscape is formed by the introduction of a number of different land and water resource uses. These include exotic forestry, mussel farming, fish farming (for example salmon) and an increase in pleasure boats. The increase in use of the Sounds has come about through both technology and an increase in economic wealth in both New Zealand and the Marlborough Region. Infrastructure is in place for these resource uses, aiding development in the region. Table 5.1 shows the resource uses of the Sounds and the subsequent landscape change.

Table 5.1: Resource use and subsequent landscape change in the Marlborough Sounds

Landscape stage	**Resource use**	**Landscape change**
Landscape one (pre European)	Native forest used for food and shelter	Natural landscape largely in tact
Landscape two (early settlement)	Wood product for housing	Much of the native forest felled for wood
Landscape three (early development)	Land for grazing sheep and cattle. Establishment of whaling industry	Land cleared by burning. Water use increased with boats for whaling.
Landscape four (expansion)	Recreation and aesthetic resource realised	Increase in residential development, roading networks and sea transport
Landscape five (reversion)	Grazing becomes an unproductive resource	Reversion of farmland to scrub
Landscape six (production mosaic)	Forestry and marine farms established, increase in commercial and recreational boating	Forestry and fish farming widespread in addition to remnants of past landscapes

Remnants of these six landscapes form the Marlborough Sounds today. Continuums of 'sub-landscapes' of total conservation to total conversion form the overall landscape. The drive to convert the pre European landscape and to develop areas has come about through global forces. These forces have influenced how people perceive and utilise the environment especially the perception that resources are not utilised to accommodate peoples needs but rather their wants. This view has led to miss-use of some developed areas, as resource use in the past has not considered environmental effects.

The present landscape of the Marlborough Sounds has resulted from land management practices, administration and regulation, the economic environment, environmental constraints and the introduction of reserves. The following section will discuss these causative factors of change in relation to the landscape of the Marlborough Sounds.

5.4.1 Regeneration

The landscape of the Sounds looks like a mosaic due to the patchy nature of the vegetation and due to the various resource uses in different areas. The vegetation pattern has been formed because some of the original forest is left and land that has been cleared for farming has regenerated at different times. The resulting landscape is a mix of pastoral land, rough pasture, regenerating scrub, advanced regeneration, self seeded pines, plantation forest and remnant native forest (Marlborough District Council, 1992a).

The perception of the reverted landscape is relatively positive. Bush that is in later successional stages is more visually attractive than farmland with patchy areas of gorse and scrub. Various stages of forestry are seen positively by the community. Times when the perception of forestry is bad is during land clearance for planting or logging. Pastoral land (although by no means natural) is accepted by the New Zealand public as natural because it is widespread and has formed the majority of the New Zealand landscape for many years. The mosaic of the Marlborough Sounds has formed due to the areas diverse stages and types of vegetation. The perception that the Marlborough Sounds is a scenic place is still very much alive, suggesting that the diversity within this landscape is appealing and interesting.

5.4.2 Administration and Regulation

The landscape of the Marlborough Sounds can be seen as an expression of administration and regulations that have been in place over the years. Initially there was little administration and settlers took land and used water bodies as they pleased whether it be to modify an area or use with disregard to effects or resource depletion. This was the product of a society who had development in mind and was striving to prosper on a new land.

Post war regulation was permissive to economic gain and little forethought was given to the sustainable use of resources. The Town and Country Planning Act (1977) promoted a wise use of resources and focused on the use of resources. The Resource Management Act (1991) introduced a significant change in legislation in New Zealand. Rather than focusing on a wise use of resources a sustainable use of resources has been adopted.

This Act aims to improve development by giving resource users and governing bodies incentives to come up with new imaginative ways to reduce the effect of activities on the environment.

One of the big problems in the Management of the Marlborough Sounds area has been that in the past there has been a number of governing bodies with little communication between departments and this has led to poor planning in some areas. Ponder (1986), outlines the boards, councils, authorities and government departments with direct or indirect control of activity and administration of the Sounds as shown in Table 5.2.

Table 5.2: Authorities with direct or indirect control of activity and/or administration in the Marlborough Sounds (modified from Ponder, 1986).

Date	**Authority**
1940-1935	None, then under Nelson jurisdiction then Marlborough Provincial Council followed by New Zealand Government rule.
1935-1955	Kenepuru Roads Board established.
World War II	Military Controls.
1955-1965	Lands and Surveys Department declared ownership of Kings and Queens Chain. Harbour Board extended its boundaries to the Sounds (1958).
1965	Marlborough County Council took control when it amalgamated with the Kenepuru and Croiselles-French Pass Roads Boards.
1975	Maritime Park Board set up to administer Government parks and reserves including the Kings Chain (promotes conservation, recreation and public access).
1976	Marlborough County Council became bigger after amalgamation of other counties. Produced a District Scheme Plan for the Sounds.
1977	Marlborough Catchment and Water Board extended function to the Sounds (concerned with soil erosion, flooding, water quality and land clearance).
1981	Marlborough Sounds Maritime Planning Authority set up under the Town and Country Planning Act (1977) to achieve an acceptable balance between conservation and utilisation of resources.
1987	Department of Conservation formed from amalgamations of parts of New Zealand forest Service, Department of Lands and Survey and the Wildlife division of Internal Affairs.
1989	Amalgamation of Picton Borough Council and Marlborough District Council.
1989	Amalgamation of Marlborough Catchment Board, Regional Water Board, Marlborough Harbour Board and Noxious Plants and Pest Authority with Nelson equivalents to form the Nelson/Marlborough Regional Council.
1992	Nelson/Marlborough Regional Council disestablished. Functions transferred to the Marlborough District Council, which became a unitary authority with regional planning responsibilities.

Other miscellaneous authorities included, Marlborough Regional Development Council (concerned with new developments such as forestry), Ministry of Agriculture and Forestry (advises and makes recommendations on forest management), Ministry of

Fisheries (issue licences for shellfish farms and commercial fisherman, and advises farmers), Transport Department (including both the Marine Division and Civil Aviation) and the Tourist Publicity Department.

Today, New Zealand has laws with the ethic of sustainability in mind. Under this ethic, environmental degradation is no longer an acceptable price to pay in the pursuit of economic growth (Ministry of Environment, 1997). Management of the environment and natural resources are undertaken through the Resource Management Act (1991).

A limitation of the Resource Management Act (1991) is that it perpetuates the division of administration for land and sea, by using a notion of high tide level being a firm line (which in reality is not fixed in space or time). The Regional Coastal Plan integrates across Mean High Water Springs but this is not included in the Regional Plan (Figure 5.3). The Marlborough Authorities have however integrated their planning by making their Coastal Plan part of their Regional Plan, leading to greater integration of management. This amalgamation of management has come about partly through the decision for the council to be a unitary authority under the Resource Management Act (1991). This holistic approach to management in Marlborough is important in the context of the Marlborough Sounds as the overlap between catchment and coast is widespread. The present study emphasises that the land and sea overlap and form a continuum, each affecting the other. The need for a continuous management regime can be highlighted in the following processes;

- physical processes – waves, currents leading to sand transport and erosion and catchment changes influencing the adjacent coast,
- biological processes – with such animals that spend some of their life on land and in water, or live on the land and feed from the water (for example, birds),
- human activities – human perception of the coast is based on the amenity (which is based on natural characteristics, such as diversity and naturalness) and recreational values that area possesses. People see the coast as a continuum rather than divisible at Mean High Water Springs (van Roon, no date given).

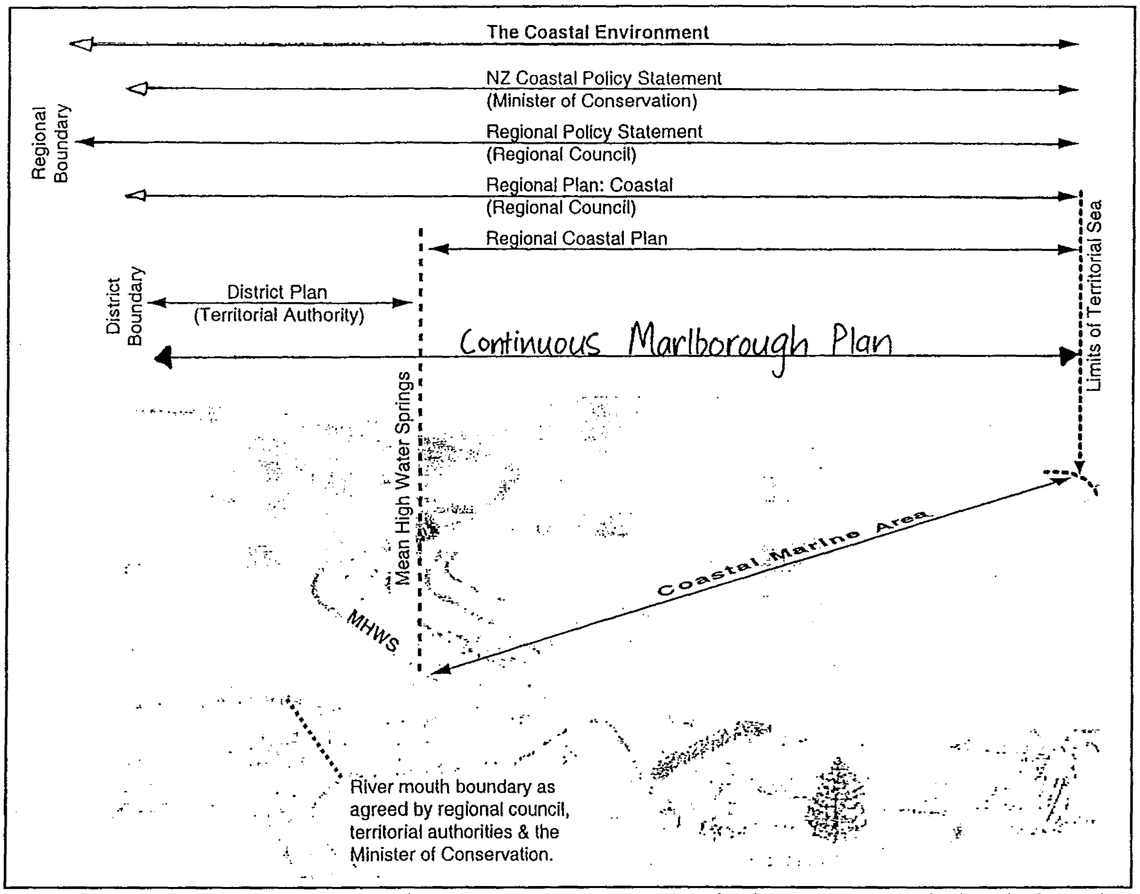


Figure 5.3: Shows the continuous management of the coast and land by the Marlborough Unitary Authority.

Thompson (1987, cited in van Roon) suggests that New Zealanders are biased to protect the visual qualities of the coast, and this could endanger the ecological management of it. This view can be highlighted by the case of fast ferries, where people viewed the coastline to be less aesthetically pleasing as the higher energy waves from the ferries have, in some areas, removed sand and replaced it with coarser material from offshore. However, most of the beaches are in a 'healthy' state and are not eroding at greater rates during the fast ferry season over summer than when fast ferries are not operating.

5.4.3 Economic Environment

The current environment of the Marlborough Sounds also reflects changing economic opportunities. Farming, forestry, marine farming, the technological possibility of having fast ferries have all been economic opportunities that the people of New Zealand have recognised as being a resource that is profitable in the Marlborough Sounds area. Resources such as recreation in the Sounds using privately owned pleasure craft and the ability of some New Zealanders to own a holiday home has arisen as the economy of New Zealand and Marlborough has grown more prosperous. This links to development of other resources in the areas such as viticulture. Thus, the Marlborough Sounds landscape has developed due to a variety of economic factors especially due to the growing wealth in the wider area.

5.4.4 Environmental Constraints

The mosaic of the Marlborough Sounds has been formed through the opportunities of the unique environment of the Sounds but also through its environmental constraints. Land use has been controlled by slope and soil type in many areas, limiting crop type or prohibiting all land use. Management of the land has been difficult as productivity of farming on the steep, quickly regenerating slopes is low. Water uses have been opportune due to the high water quality standards of the Sounds for mussel farming and fishing and recreation. It has also been used as a sheltered transport route for shipping, both commercially within the Sounds and between the two main islands of New Zealand. Environmental constraints such as the large swells in Cook Strait postponed the introduction of fast ferries in the area, as technologically no boats could cross the rough waters of the channel at high speed.

5.4.5 Introduction of Reserves

Natural processes and the need for holistic management of ecosystems have, since the time of European settlement, played little part in determining the focus of individual statutes in New Zealand (van Roon). The introduction of reserves of parts of ecosystems in the Sounds showed early attempts to conserve some communities. Appreciating the need for holistic management of regions aids in humans understanding of land-water relationships. It certainly aided this study as reserves at Jacobs Bay have shown the contrasts in the coastal environment due to the different catchment uses.

5.5 Role of the coast in the Marlborough Sounds

In most parts of New Zealand the coastal zone is characterised by interactions between human uses of the land and water and natural coastal processes (Sutherland *et al.*, 1992). These interactions can sometimes lead to alteration of the coast that can be irreversible. Because of the strong interaction between the coast and its adjacent areas (that is, land and sea), it is important that the coast is managed and viewed as a continuum of land to water or vice versa. This section discusses the perception of the coast to New Zealanders and emphasises the need for holistic management of the coast.

The perceptions of land and water uses in the Marlborough Sounds are quite different. The sea has been considered common property since Grotius stated in his 1633 treatise, The Freedom of the Seas, that the use of the sea should be free, in the sense that 'all citizens have equal and indiscriminate right to use rivers and public places' (cited in Gardner, 1984, P.36). The perception that water can not be owned, and it is everyone's right to use that space has led to controversy over the influx of Marine Farms present in the area and the problems outlined in Chapter Three over the introduction of fast ferries to the Ferry Corridor.

In a recent article from the Christchurch Press, marine farming as a water use was discussed (The Press, 27.07.2000, P.7). It posed the question,

> 'Why is the aquaculture industry able to use a public resource for private, commercial gain with no return to the public?'

This perception has arisen due to the dominance of public rights on the seaward boundary of Mean High Water Springs (MHWS). Conflict has resulted, as people have had to change their use of many areas of the Sounds as resource use of the water has increased and changed.

However, land is perceived quite differently. 'Property' is derived from the Latin word *proprius*, meaning, 'own or proper' (Kirkpatrick, 1996). It is important that landowners do not perceive that private property equates private rights. This has been the perception in the past but this view can lead to conflict if land uses conflict with other uses in the area. Land is perceived to be privately owned and what is carried out on that land and how the landowners utilise the resources that are on it, is up to them. Private property rights through the government have aimed to balance private rights and public good. Today, under the Resource Management Act (1991), land and water uses must reduce effects on both the environment and other uses in an area.

Straddling these two areas of different property rights, public and private, is the coast. It is very difficult to manage these regimes side by side and the coastal zone is in endless contention as to its management and its use. A bipolar view of the coast is present, where adjacent landowners perceive the area as their private property and other users perceive it as public land. This leads to conflicts when landowners use it as if it was theirs by changing some of the coasts properties (for example increasing the amount of fine sediment on the beach through forestry practises).

Most New Zealanders view the coast as having impressive natural scenic beauty, and a great place to visit for recreation. However, few New Zealanders would perceive the coast as a resource in the same way as minerals or forests (Healy, 1980). Development and modification of this resource is ever present, for example in the Marlborough Sounds introduced waves are altering beach sediment and the sedimentation from catchment change and land erosion modifies beaches and the nearshore zone. Conservation of this resource does not necessarily mean preservation but preservation should be an integral part of the process of conservation. Preserving the entire coastline is unrealistic, development of the coast is inevitable.

Management problems arise due to the multi-functional role of coasts. In the Marlborough Sounds many land and water uses depend on the coast whether it be for loading, transport, recreation or waste water discharge to name a few. The importance of the coast in the context of the Marlborough Sounds highlights the need for it to be managed effectively as a resource.

5.6 What of the future – planning and management

The future of the Marlborough Sounds depends on how we plan and distribute resources. The value of the area must be recognised so we can preserve areas now before development takes over. This is meaningful at a local scale, as planning must be undertaken to allocate space both for development and preservation.

The landscape is important to New Zealanders for its resources and amenity. This importance is highlighted in the Resource Management Act (1991) where in section five it states that development must avoid, remedy or mitigate any adverse effects on the environment (including amenity values). The 'protection of outstanding natural features and landscapes from inappropriate subdivision, use and development' is considered of national importance in Section six of the Act. Section seven of the Act states that particular regard to "the maintenance and enhancement of amenity values" must be undertaken. These examples of policy statements that recognise the landscape are a credit to how New Zealanders view landscapes like the Marlborough Sounds are of high importance.

Glendall *et al.* (1994, cited in Ministry of Environment, 1997) report that people are also becoming more aware of sustainable practises than ever before. In a national poll (1993), two thirds of the 70% who responded said that, if necessary, they would accept a drop in economic growth in order to protect the environment. Because of this environmental awareness, many large companies are prepared to avoid major impacts on the environment, because of the possible outcome of bad publicity.

The Nature Conservation Council (1981, P.18) state that

> 'Many people feel a sense of unease and insecurity at the rapid, man-caused changes that New Zealand's landscapes and natural systems are undergoing and fear that the country is losing its distinctive natural character'.

The New Zealand community is growing an identity with the landscape and their involvement is empirical for sustainable management practises to be carried out and with this enthusiasm for sustainable practises the Resource Management Act should work well in the Marlborough Sounds.

There are a number of policy options outlined in the paper considering Issues and Options for Forestry and Farming in the Marlborough Sounds, produced by the Marlborough District Council (1992). Options for management include;

- do nothing,
- education – increase understanding of sustainable management,
- incentives – such as subsidies, tax relief for assistance with works programs,
- Statutory controls – targeting specific activities, effects or areas.

All options need to be workable, fair, cost effective and be publicly acceptable. Rich and Shaw (1993) suggest that an option is to set up scenic corridors. On land, vegetative cover would be native and maintained and the coastal environment free of structures. An example of this is already in place in Apuau Channel (Rich and Shaw, 1993).

Planning requires subjective judgements on aesthetic impact, leading to inconsistent and arbitrary applied rules (Cats-Baril and Gibson, 1987). Assessing the aesthetic quality of land and water development is becoming an increasingly important part of local and regional regulatory functions. In most instances, decisions on land development continue to rely on more measurable criteria such as water quality, even though aesthetic quality may be of equal or greater importance. The Marlborough Sounds region relies heavily on aesthetic resource values for tourism and recreation uses. It is difficult to gauge just what changes in the Sounds the landscape can absorb without a significant loss of aesthetic or scenic attraction. The task of evaluating aesthetics is complex but as awareness of the importance of landscape beauty increases so does the necessity for it to be addressed in planning (Cats-Baril and Gibson, 1987).

It is important that we realise that what is needed in the context of the Marlborough Sounds is a resolution rather than a solution. Johnston (1987) argues that we should not assume that all problems, especially those problems relating to people are capable of solution. The concept of a solution suggests the existence of a single right answer that can be identified and imposed. The situation in the Marlborough Sounds has no solutions but will depend on resolutions to reduce the impact of land and water uses on the coastal region that are relatively satisfactory to both sides. In order to have a resolution, that works for all sides of the situation, mutual understanding and appreciation of different sides of the argument by all concerned is important.

5.7 Cost/benefits of conservation/development of the landscape

The problem with environmental planning is that development and conservation are often viewed as opposite or mutually exclusive rather than interdependent actions (Nature Conservation Council, 1981). Both can be employed during land or water use if appropriate management strategies are in place.

McNeely (1991), states that the world is being impoverished by the loss and degradation of its most fundamental capital stock – its genes, species, habitats, and ecosystems. The pace at which this phenomenon has been occurring in recent decades is unmatched since the dinosaurs died out 65 million years ago. This loss of the living richness of the planet has profound implications for development. Instead of conserving the rich resources of forest, wetland and sea, current processes of development are depleting many biological resources at such a rate that they are rendering them non-renewable. McNeely continues to say that the roots of the problem are found in the distribution of costs and benefits of both over-exploitation and conservation.

Costs and benefits of any decision are important in the process of planning land or water use. Costs and benefits may have different weightings, not all costs or benefits are necessarily monital. Some decisions are made on social or ethical weighting's not just on economic gain. In the Marlborough Sounds development has monital gain. Because the area has uses that rely on conservation, benefits from development do not necessarily outweigh the social benefits of conserving the Sounds. Many, for example recreational users, pay the cost of exploitation. The loss of biological diversity shown in our native forests results in future generations not seeing this diverse community. By causing ecological damage development is likely to cause economic and social damage.

To achieve the objectives of conservation, governments must dispel the notion that conservation is limited and concerned with wildlife or soil and a hindrance to development. It is important to have an open mind about conservation concepts so they can be written into policies. For example ecological concerns that are seldom anticipated before development can arise and result in environmentally expensive mistakes (World Conservation Strategy, 1980).

Oscar Wilde's definition of a cynic is someone who knows the price of everything but the value of nothing. It is difficult to put a value on the benefits of conservation and biodiversity as nature is so complex, subtle and intangible. Being able to place a financial value on at least some of the attributes of the environment will help encourage investment in its conservation (McNeely, 1991). Leopold (1969) and Linton (1968) (both cited in Cooke and Doornkamp, 1974) have proposed methods of appraising landscape components but these are not employed in New Zealand to date.

McNeely, (1991) identifies three broad options for governing resources. These are, to manage a sustainable yield and maintain the future option of depleting a resource; draw down supplies slowly in an effort to spread earnings over many years; or deplete existing stocks quickly, getting a quick profit in return. For conservation the first option would be the most preferable, but often the third option in the case of forests and fisheries is employed. In the Marlborough Sounds the first option is employed in most situations. As discussed earlier the Resource Management Act (1991) promotes the sustainable use of resources. Most of the major resources in the Sounds are renewable (for example; forestry, mussel farming, transportation and recreation) and sustainably utilised.

Direct benefits accrue from sustainable harvests of biological resources, contributions to ecological functions, tourism, and other measurable goods and services, including maintenance of ecological functions (McNeely, 1991). The raising social question is 'what level of ecological disruption is acceptable for what level of economic expansion?' (Schnaiberg, 1975, P.7). Resource use in the Marlborough Sounds has disrupted some ecological processes in the area. For example, forestry's effect on natural flora and fauna through increasing sedimentation levels in the water, reduction in habitat and encroachment of wilding pines on native bush. However, the economic gain from expansion of forestry has been high. In most stages of the growing cycle this resource use has been beneficial to the environment of the Sounds.

Lucas (1977), states that tourism can provide an economic justification for conservation of the environment by promoting a greater public awareness of it and support for its conservation. But if over developed or uncontrolled, tourism can endanger natural areas, through visual and cultural pollution and hence, destroy the very resources on which it is based. A social evaluation is clearly important in finding the principal role which recreation plays in the Marlborough Sounds usage. Such a valuation can decide the future role of the coastal zone for recreational purposes and whether environmental aspects should be maintained. Currently many areas of the Marlborough Sounds are utilised for recreation. Walks such as the Queen Charlotte Track are heavily utilised especially in summer months. Recreation in the Sounds is generally heaviest in summer. Boating is a tourist/recreation resource that is popular in the Sounds (outlined in Chapter Two). On weekends and public holidays the sea scape of the Sounds looks very different to a normal weekday as boat numbers increase rapidly on these days. The wakes from these vessels are interacting with the coast and water pollution can result from fuel and peoples discarded rubbish. Over population of a normally underpopulated area can result in the environment being degraded.

Those that live in the vicinity of the resource (ie. the area of the Marlborough Sounds) unfortunately can not win with conservation or development. If the area is totally conserved then the people loose the ability to access the resources that they have utilised for so long. Whereas if the area is developed they do not necessarily benefit from the economic returns and their lifestyle may be altered both in access to the resource and quality of life in a potentially industrial environment. An example of this occurring in the Sounds can be identified in fish as a resource use. Over the years the Marlborough Sounds have been heavily utilised for its fish resources both for commercial and recreational fishing. Over time development of this resource has resulting in fish numbers decreasing. There are areas under reserve which are rich in fish resources but are protected from the removal of fish. The fish resource of the Marlborough Sounds has been utilised by local residents for food over the years but this resource is dwindling due to both conservation and development.

5.8 Summary of resource use and landscape change in the Marlborough Sounds

In the past, News Zealand's pioneer mentality was that when a resource is discovered the immediate question is how do we exploit it, not should this resource be used (exploited). Linkages exist as to how New Zealand people relate to the environment and its resources. These include links between;

- high technology agriculture and water and soil resources,
- foreign investment in New Zealand and less control over the development of our country,
- personal lifestyle and the environment. As long as we aspire to owning and using more, then we only contribute to these problems. An increase in quality of life should be our aim, rather than an increase in GNP.

(Baker, no date given)

In the process of developing the Marlborough Sounds resources, the landscape has been greatly altered. This chapter has identified six landscapes in the Marlborough Sounds in the last two centuries and has linked landscape change to resource use, management, economics, environmental constraints and management. This alteration has rarely been accompanied by an awareness of the values being sacrificed or created (Anstey et al. 1982). The challenge that faces us is to acknowledge the process of change and apply this awareness to creative action.

Decisions about how to change land and water cover may be made by individual land and water owners, but their impacts are seen cumulatively as a change in spatial pattern on the landscape. The landscape scale is important as decisions are made on a broad scale in order to manage natural resources, for example, river basins or forest districts or The Marlborough Sounds Region (O'Neill *et al*, 1997). The conservation and development of the Sounds has been reviewed in this chapter and the costs and benefits of these options discussed. It has been suggested that the cost of development is paid by the local residents, and by people using the Sounds for tourism and recreation. The benefits of development are land and water owners who gain economic benefits from resource use.

The importance of the coast as a resource has been identified in this chapter. The concept of the coast straddling two areas of different property rights, public and private has been developed. It has been suggested that this leads to difficulties in management of this heavily utilised, multifunctional area

There is no easy answer to ethical, philosophical, and ecological arguments about the land and water use in the Marlborough Sounds. Expectation to develop will continue, resulting in a need to put management in place. It is socially desirable to leave areas in the Sounds undeveloped, as the area will loose its aesthetic appeal and identity.

The Ministry of the Environment (1997, P.1:3) puts forward some sound advice - 'we may legitimately ask whether it was necessary to destroy quite so much forest, drain quite so many wetlands, introduce quite so many alien species, create quite so much pasture and extinguish quite so many native species, but we cannot undo history. We can only learn from it and try to do better'. Marsh (1864) states that, 'to the common observer, the power most important to cultivate, and, at the same time, hardest to acquire, is that of seeing what is before him. Sight is a faculty; seeing, an art'. It is important that in the context of the Marlborough Sounds, we learn from our past mistakes and plan by seeing what is before us. We must strive to make the Sounds a sustainable place, through use of its resources and by identifying and managing landscapes that people enjoy today and can enjoy in the future.

CHAPTER SIX

Conclusion

View from the rear of Top Cat fast ferry, with the landscape of the Marlborough Sounds in its wake.

'We have not inherited the earth from our parents we have borrowed it from our children' (Nature Conservation Council, 1981, P.10).

6.1 Thesis goal revisited

This thesis has discussed the changing landscapes of the Marlborough Sounds and the effects of the changes on the coastal zone. Rather than answering a question this document has examined the landscape of the Marlborough Sounds and enquired into how it has reached its current form. The importance of this exercise is evident in the need for people and organisations to understand and identify past events in order to plan for future landscape change in the Sounds.

Discussion of the resource use of land and water in the Sounds focusing on the water use of fast ferries and the land use of forestry has highlighted the resource richness of the region. The demands for resources in the Sounds have come from a variety of resource users (many of whom have emerged from the everyday reality of getting a living), challenging planners to accommodate the needs of all affected by current change.

This thesis set out to examine the changing landscapes of the Marlborough Sounds and the effect of this on the coastal zone. Landscape change was identified through the historical examination of resource uses in the area over time. It was established that in the last two centuries there have been six major landscapes of the Marlborough Sounds related to resource use.

The effect of resource use on the coastal zone was discussed through the landuse of forestry and the water use of fast ferries. It was found that land and water use in the Sounds is changing the coastal zone but that one resource use can not be looked at in isolation from other resource uses or from natural processes that are also having an effect. Quantifying the effects of different land uses on the coastal zone is not possible due to the complexities of the human and natural processes in the Sounds.

Finally this thesis aimed to discuss the management of the Sounds and how this has formed the current situation. The changing management was identified in the resource studies on forestry and fast ferries. It was found that management has reflected the perception of resources and their use. The Marlborough Sounds have had a disjointed management regime over the years but with the introduction of the

Resource Management Act (1991), resource use and the effects of resource use are being managed in a more holistic way.

6.2 Landscape change

It has been said by many geographers that in both the physical and cultural world nothing is constant but change. This is true for the landscape of the Marlborough Sounds especially over the last 150 years. Although change of the landscape has occurred, change is not necessarily detrimental. Change is always occurring in the environment but is brought about more rapidly with the presence of humans. Landscape change has occurred as resources have been realised and utilised and as the technology has enabled us to utilise them economically. The Marlborough Sounds contain many resources which have been subject to changing perceptions and value over time. This thesis has identified that there has been six landscapes in the Marlborough Sounds in the past two centuries. The changes in landscape outlined in Chapter Five are; pre European (value for natural habitat for food), early settlement (native timber clearance used for building), land clearance (for grazing), expansion (for recreation and residential development), reversion (as farming becomes uneconomical), and production (of forestry and fish farming).

Before European occupation the landscapes of the Marlborough Sounds were dominated by native bush. This landscape was valued as a resource as it provided the Maori people with food and shelter and so was preserved in this form. When Europeans came to the Sounds, the native forest was perceived as a resource for its timber products that could be utilised for building. Therefore the easily accessible areas of forest were felled. Gradually the Marlborough Sounds were perceived as a resource for grazing. Thus much of the remaining forest was burnt and the landscape changed from native forest to pasture. As the Sounds became more developed for farming, roading networks and infrastructure such as ports were developed. This in turn made the Sounds more accessible to people to realise the scenic value of the area. Thus expansion of residential and recreational use resulted. Grazing in the Sounds became uneconomic during the depression and during World War II when meat and wool prices were low. At this time much of the land reverted to early successional forest. To replace this land use with another more profitable resource (and through governmental pressures as wood resource was seen to be scarce for the future), some farmers planted exotic forests. At this time mussel and fish farming became a profitable water use. As the resources became technologically and environmentally possible and, socially and economically desirable they were utilised so forming the present mosaic of the Marlborough Sounds.

The reasons for landscape change thus relate to resource perception change over time. One of the factors causing the landscape change from grazing to forestry includes the changing perception of forestry as an accepted landuse and more profitable than farming. The resource perception and change over time for transport by water is seen in the change from conventional to fast ferries as demand for a faster service has made this an economical and socially desirable resource.

This thesis has identified that the landscape has also changed as a reflection of management over many years since early settlement, both in on farm and local (district) decisions and government regulations. Today, the Resource Management Act (1991) is aiming towards sustainable development under the management of the Marlborough District Council. This concept has so far proven to work well in the Sounds area. This Act is not in place to hinder development but to reduce adverse effects of development. Therefore development in the Sounds should continue as long as users minimise adverse effects from resource use. Williams (1985, cited in Kirk, 1992) states that the planning system exists for orderly, civilised management of change in our spatial environment. This is reflected in the Marlborough Sounds environment which is undergoing constant environmental change and hence requires changing management strategies to accommodate these changes.

Future development in the Sounds will be a contentious and complicated issue. Both development and conservation can occur side by side with careful planning and management objectives. Already areas of the Sounds have been reserved for conservation. These areas of conservation are considerable but disjointed. They act as a start point of possible future movement towards a greater area of land and sea under conservation management (ie: reserves). This should be done with continuous management from peaks to the sea. Total conservation of the area is unrealistic due to the resource base and existing property rights of individuals and organisations.

Resource perceptions and change in them over time for transport by water are seen in the change from conventional to fast ferries as demand for a faster service has made this an economical and socially desirable resource.

6.3 Coastal change

Within this broad landscape change of the Marlborough Sounds, land and water use over these years has led to the alteration of adjacent areas such as the coastline. Beaches are among the most dynamic and changeable landforms on the earth. They consist of the weakest materials known to science (a mixture of sand and water) and change by the minute, hour, day... in response to changes in wave type, weather, sea level, adjacent catchment changes and actions of humans (Kirk *pers comm*, University of Canturbury, 2000). It has been found that the coastal area of the Marlborough Sounds has been changing, often not only due to human actions but natural phenomenon also.

The present study on the changing land and water uses in the Sounds has highlighted the influence of both natural and human devices in coastal change. Results of studies of coastal change after the introduction of fast ferries into the Sounds revealed that many processes were occurring. Processes causing beach change include the natural steep short period waves that are highly erosive and work the beaches in the Sounds constantly at different energy levels depending on wind speed and fetch length, or the building of structures on the shore that result in changes in sediment transport along the shore.

The study in Chapter Four on land use change has shown that forestry had predictable changes on the coastal system. However most of these changes have been short term. The coast forms a new equilibrium and removal or deposition of sediments occurs accordingly with changes to land use. Changes that have been found to occur as a result of forestry practises occur at the beginning and end of the growing cycle of the forest. When land clearance is taking place either to establish or harvest a forest crop, it has been identified that an increase in sedimentation occurs in enclosed bays immediately adjacent to the effected catchments and suspended sediment levels also increase. It was found however that the Pelorus River has a significant effect on both sediment levels in suspension and on the Pelorus Sound seabed to Tawhero Point and beyond. This natural system has for centuries been causing the Pelorus Sound to infill and is causing changes to beach morphology of an equal magnitude if not more than adjacent catchment uses.

This study emphasises the need for a wide perspective when viewing situations and formulating cause and effect. Often the situation can be misleading. The need for constant monitoring and data gathering is imperative in making management decisions in an environment that is as dynamic as the coast.

6.4 Towards the future – a sustainable Marlborough Sounds

What has occurred in the past cannot be undone, only learned from. The option of transforming the landscape back to how it was is unrealistic. The future of the development of the Marlborough Sounds lies in the hands of managers and the community. The community must have goals in accordance with management organisations if the process of sustainable development in the Sounds is to be realised. As far as landscape change is concerned there are two main long term options. These are to develop appropriate areas and reap benefits economically, or conserve areas and have aesthetic pleasure from them. There is much debate locally, regionally, nationally and internationally as to how to deal with this problem of use verses preservation or conservation. Although the land and water uses of the Marlborough Sounds is a regional example it has wide spread international context.

6.5 Future study

An interesting avenue for future research would be to evaluate the economic gains from developing the area for its resources in agriculture, forestry or mussel farming to name a few and the gains in conserving the area and putting in place infrastructure for the possibility of ecotourism. This could be undertaken at a small scale, for example a couple of valleys or larger scale with the assessment of a whole sound. Potential for aesthetic values to be a profitable resource is high, as development internationally has restricted the amount of natural scenic areas so they become a scarce resource in themselves.

6.6 Final remarks

The Marlborough Sounds is a precious area. Not only is it sensitive to change but it is important to people for its resources both on land and in water, economically, ecologically and culturally. New Zealanders have taken for granted their good luck in being surrounded by an amazing landscape holding within it such an array of treasures. They have utilised the land and water both prior to and including European colonisation of New Zealand, and now it has reached the point where natural landscapes are so few that they are valued highly because of their rarity. I plead with all people in positions of authority for the management and implementation of management in the Sounds, to consider long-term benefits instead of short-term gains as far as landscape change is concerned. In the past some have been eager for change, and where has it taken us? Vast amounts of money have been spent on development since 1840, soils have been degraded, a significant loss of native species and a patchy landscape has occurred. I hope this thesis stimulates thought on the changing landscape of the Marlborough Sounds and I trust that those who influence the decisions on development proposals will make wise decisions.

References

Amendments of the Commercial Forestry Consent Order, 1991, Marlborough District Council respondents before the Environment Court in the matter of seven references under Clause 14 of the First Schedule of the Act.

Anstey, C., Thompson, S., and Nichols, K., 1982, Creative Forestry. Hasselberg, Government Printer, Wellington, New Zealand.

Ash, J. H. 1997, Morphodynamics of Tory Channel Beaches as a Result of Seasonal Artificial Wave Action. Thesis presented in fulfilment of a Master of Science degree at the University of Canterbury.

A strategy for the conservation and development of the Marlborough Sounds. 1976, compiled by Ministry of Agriculture and Fisheries, New Zealand Forest Service, Department of Lands and Survey, Ministry of Works and Development.

Baker, M., no date given, Introduction of Environmental Perspectives. Environment Group. Auckland.

Bell, D. H., 2000, Preliminary Engineering Geology Evaluation of Slope Instability along the Ferry Corridor. Report to the Marlborough District Council.

Boak, E. H., 1996, Characteristics and Effects of Vessel Generated Waves, Torpedo Bay, Auckland. Thesis presented to the University of Auckland in partial degree of a Master of Science in Environmental Science and Geography.

Bowie, I. J. S., 1963, Land Utilisation in the Marlborough Sounds. Unpublished thesis presented in partial fulfilment of the requirements for the degree of Master of Arts in Geography, University of Canterbury.

Boyce, A. G., 1971, Coastal Depositional Environments of the Inner Marlborough Sounds. Unpublished thesis submitted in partial fulfilment of the requirement of the degree of Master of Arts in Geography.

Carson, R, 1963, Silent Spring. Hamish Hamilton Ltd. Great Britain.

Carter, L., 1976, 'Seston transport and deposition in Pelorus Sound, South Island, New Zealand' in New Zealand Journal of Marine and Freshwater Research. 10:263-282.

Cats-Baril, W., and Gibson, L., 1987, 'Evaluating landscape aesthetics: A multi-attribute utility approach' in Landscape and Urban Planning. 14:463-480.

Coker, R. J., 1994, Sedimentation and Forest Harvesting in the Marlborough Sounds. Unpublished report prepared in partial fulfilment of the degree of Master of Forestry Science. University of Canterbury.

Coker, R. J., Fahey, B. D, and Payne, J. J., 1993, 'Fine sediment production from truck traffic, Queen Charlotte Forest, Marlborough Sounds, New Zealand' in Journal of Hydrology. (New Zealand) 31:56-64.

Cooke, R. U., and Doornkamp, J. C., 1974, Geomorphology in Environmental Management. Clarendon Press, Oxford. First Edition.

Croad, R. D., 2000, Navigational Bylaw 2000, Analysis of Ferry Wave Data from the Marlborough Sounds. Opus International Consultants LTD. Wellington.

Danish Maritime Authority, 1996, Technical investigation of wake wash from fast ferries. Danish Hydraulic Institute, Denmark.

Danish Maritime Authority, 1998, 'The environmental impact of high-speed ferries' in Seaways. October, 1998.

Danish Hydraulic Institute, 1998, Wake wash measurements at Hobart, Tasmania. Hørsholm, Denmark.

Davidson, R. J. 1995, Preliminary observations of disturbance in Tory Channel, Queen Charlotte Sound. Department of Conservation.

Dew, D., 19.01.2000, Mr Dew owns a batch at Long Beach and is a Marlborough Councillor.

Dick, J. E., Erdman, M. R. and Hanes, D. M., 1994, 'Suspended sand concentration events due to shoaled waves over a flat bed' in Marine Geology. 119:67-73.

Fahey, B. D. and Coker, R. J., 1989, 'Forest road erosion in the granite terrain of south-west Nelson' in Journal of Hydrology. (New Zealand) 28:123-141.

Fahey, B. D. and Coker, R. J., 1992, 'Sediment production from forest roads in Queen Charlotte Forest and potential impact on marine water quality, Marlborough Sounds, New Zealand' in New Zealand Journal of Marine and Freshwater Research. 26:187-195.

Fejos, P., 1956, 'Forward' in Man's Role in Changing the Face of the Earth. University of Chicago Press. Chicago.

Feldtmann, M. H., 1997, 'High speed sea operations near sensitive shorelines' in Combined Australasian Coastal Engineering and Ports Conference. Christchurch, New Zealand.

Field, D. A., 1976, Implications of Exotic Forestry for other Resource Uses in the Marlborough Sounds. Unpublished Masters thesis submitted in fulfilment of a Master in Science in Resource Management. Lincoln College.

Froude, W. W., 1877, 'Experiments upon the effect produced on the wave-making resistance of ships by length of parallel middle body' in Transactions of the Institute of Naval Architects. 18:77-97.

Gardiner, J. 1982, Policy and institutional arrangements for coastal conservation in the Marlborough Sounds. Extracted from a thesis being prepared for the Geography Department, University of Canterbury. Published by the Marlborough Sounds Maritime Park Board.

Gardner, J. E., 1984, Coastal Conservation in New Zealand. Thesis presented for the degree of Doctor in Philosophy in Geography at the University of Canterbury, New Zealand.

Gerrad, P. N. and Hey, R. D., 1987, 'Boat traffic, sediment resuspension and turbidity in a broadland river' in Journal of Hydrology. 95:289-297.

Goudie, A., 1994, The Human Impact on the Natural Environment. Fourth Edition, MIT Press, Cambridge.

Goudie, A. and Viles, H., 1997, The Earth Transformed. Blackwell Publishers Ltd, Oxford.

Grant Cameron, 05.09.2000, A lawyer from Grant Cameron and Associates and a litigation law expert. Proposes to undertake a class action over ferry wash damage on behalf of residents in the ferry corridor.

Griffiths, G. A., and Glasby, G. P., 1985, 'Input of river derived sediment to the New Zealand continental shelf' in Estuarine, Coastal and Shelf Science. Vol 21: 773-787.

Havelock, T. H., 1908, 'The propagation of groups of waves in dispersive media, with application to waves on water produced by a travelling disturbance' in Proceedings of the Royal Society of London. Series A: 81:398-430.

Havelock, T. H., 1931, 'Ship waves and calculation of wave profiles' in Proceedings of the Royal Society. Section A – Mathematics and Physical Science. P.1-13.

Havelock, T. H., 1932, 'Ship waves: their variation with certain systematic changes of form' in Proceedings of the Royal Society. P.465-471.

Havelock, T. H., 1935, 'Ship waves: the relative efficiency of bow and stern' in Proceedings of the Royal Society. P.417-426.

Hay, D. 1968, 'Ship waves in navigable waterways' in Proceedings of the 11th Coastal Engineering Conference. 1:95:1472-1487.

Heath, R. A., 1976, 'Broad classification of New Zealand inlets with emphasis on residence times' in New Zealand Journal of Marine and Freshwater Reseach. 10:429-444.

Hedén, M. and Borgström, S. 1999, 'Exotic forestry in the Nelson region – From pasture to pine plantations – improving sustainability or not?' in Geographical studies in Aotearoa, 1999. Hultblad, G. and Kinlund, P. Eds. Kulturgeografiska institurionen och, Stockholm.

Heijman, W. J. M., 1991, Depletable resources and the economy. Wageningen: Agricultural University, Wageningen, Netherlands.

Henderson, E. and de Lambert, R., no date given, Landscape values and Resource Management. Ministry for the Environment, Wellington.

Hilton, J. and Phillips, G. L., 1982, 'The effect of boat activity on turbidity in a shallow broadland river' in Journal of Applied Ecology. 19:143-150.

Hocking, D., 1994, On becoming respectable. New Zealand Forest Industries, July, 1994. Profile Publishing Ltd. Auckland, New Zealand.

Humphrey, C. R., and Buttel, F. R., 1982, Environment, Energy and Society. Wadsworth Publishing Company, California.

Johnson, J. W., 1969, 'Ship waves at Recreational Beaches' in Shore and Beach. P.11-15.

Johnston, R., 1987, 'There's a place for us' in Geography: a Celebration. Proceedings from the Geography Jubilee, 1937-1987, Department of Geography, University of Canterbury. P.26-42.

Johnstone, A., Mace, J., and Laffan, M., 1981, 'The saw, the soil and the Sounds' in Soil and Water. August/October, 1981. P.4-8.

Joint Centre for Environmental Sciences, 1980, Open Space, Resource Use and Management in the Marlborough Sounds. University of Canterbury and Lincoln College.

Kelvin (Sir William Thompson), 1887, 'On ship waves' in Proceedings of the Institute of Mechanical Engineers. 409-433.

Kirk, R. M., 1989, Catamaran Wake from the "Fiordland Flyer" on the Shoreline of Lake Manapouri. A report to the Guardians of Lakes Manapouri and Te Anau.

Kirk, R. M., 1995, Supporting evidence to the Planning Tribunal on behalf of New Zealand Rail Limited. Marlborough District Council and Save the Sounds v. New Zealand Rail and Sea Shuttles NZZZ Limited, (W40/95).

Kirk, R. M., 2000, Professor of Geography, University of Canterbury.

Kirkegaard, J., Kofoed-Hansen, H. and Elfrink, B., 1998, 'Wake wash of high-speed craft in coastal areas' in Proceedings of the 26th International Coastal Engineering Conference. Copenhagen, Denmark.

Kirkpatrick, D., 1996, Property Rights – do you have any? An occasional paper presented at the Resource Management Law Association Annual Conference.

Kofoed-Hansen, H., Jensen, T., Kirkegaard, J. and Fuchs, J., 1999, 'Prediction of wake wash from high-speed craft in coastal areas' in International Conference of Hydrodynamics of High-Speed Craft. London, England.

Kofoed-Hansen, H. and Mikkelsen, A. C. 1997, "Wake wash from fast ferries in Denmark" in Fourth International Conference On Fast Sea Transportation. Sydney, July 21-23. Volume One. P.471-478. Baird Publications, Victoria, Australia.

Komar, P. D., 1998, Beach Processes and Sedimentation. Prentice-Hall Incorporated. Second Edition.

Kós, S. and Bielby, S., 1995, 'Fast ferries decision: Seeing sense in its wake' in New Zealand Law Journal. November, 1995, P.363-368.

Kurata, K. and Oda, K., 1984, 'Ship waves in shallow water and their effects on moored small vessel' in Coastal Engineering. P.3258-3273.

Laffan, M. D., 1980, 'Some observations of regoliths and landslides in the Marlborough Sounds' in New Zealand Soil News. 28:96-102.

Laffan, M. D. and Daly, B. K., 1985, 'Soil resources of the Marlborough Sounds and implications for exotic production forestry' in New Zealand Journal of Forestry. 30:54-59.

Laffan, M. D. McQueen, D. J., Churchman, G. J and Joe, E. N., 1985, 'Potential site disturbance and fine sediment production from various forest management practices' in New Zealand Journal of Forestry. 30:70-86.

Lauder, G. A., 1987, Coastal Landforms and Sediments of the Marlborough Sounds. Unpublished thesis for a degree of Doctor of Philosophy in Geography. University of Canterbury.

Lauder, G. A. and Kirk, R. M., 1985, 'Sedimentation, land-use, and coastal stability in the Marlborough Sounds' in Proceedings of the Soil Dynamics and Land Use Seminar, Blenheim, May, 1985. Papers presented in a joint seminar of the New Zealand Society of Soil Science and New Zealand Soil Conservators Association. Campbell, I.B. (Ed).

Lucas, P. H. C., 1976, 'Environmental compatibility of tourism' in The Land-Sea Interface. Department of Lands and Survey, Wellington.

Maclaren, J. P., 1996, Environmental Effects of Planted Forests in New Zealand. New Zealand Forest Research Institute, Rotorua.

Maritime Coastguard Agency, 1998, Investigation of High Speed Craft on Routes near to Land or enclosed Estuaries. Research Project 420.

Marlborough District Council, 1992a, Issues and Options for Forestry and Farming in the Marlborough Sounds.

Marlborough District Council, 1992b, Toward the best: A discussion document to assist the development of resource management policy for Marlborough.

Marlborough District Council, 1992c, Malborough Sounds: Water Quality and Coastal Contamination: Issues and Options Paper.

Marlborough District Council, 06.07.2000, Navigation and Safety in Tory Channel and Queen Charlotte Sound – HO90-07. Notice of a special meeting of Council.

Marlborough Express, 12.01.1995. P.3. 'Sea lettuce strewn on once pleasant beach'.

Marlborough Express, 30.01.1995. P.1. 'Fast ferries can bring benefits in their wake'.

Marlborough Express, 11.12.1999. P.4. 'Fish Competition Results'.

Marlborough Express, 04.02.2000. P.1. 'Fast ferries pose danger, consultants tell council'.

Marlborough Express, 18.02.2000. P.1. 'Stunned Minister'.

Marlborough Express, 09.03.2000. P.1. 'Not enough evidence to slow ferries: MSA'.

Marlborough Express, 10.03.2000. P.1. 'Fast ferry helps boost Port Marlboroughs profit'.

Marlborough Express, 13.03.2000. P.1. 'Council bylaw aimed at cutting size of wave from fast ferries'.

Marlborough Express, 20.03.2000. P.1. 'Council asks what are the ferries worth?'.

Marlborough Express, 23.03.2000. P.10. 'Fears held over wash worsening landslide'.

Marlborough Express, 16.06.2000. P.6. 'Ferry speed proposal attacked'.

Marlborough Express, 04.07.2000. P.2. 'Bylaw aimed only at fast ferries'.

Marlborough Express, 03.08.2000. P.1. 'We'll sue for millions over ferry wash, says law firm'.

Marlborough Express, 06.09.2000. P.1. 'Fast Cat must pay for damage in the Sounds'.

Marsh, G. P., 1864, Man and Nature. David Lowenthal Editor. Harvard University Press, Cambridge.

McGregor, H., 1997, How and why do the perceptions of forestry on farmland differ between farm foresters and graziers in New Zealand? Dissertation submitted in partial fulfilment of the requirements for the degree of Bachelor of Forestry Science. University of Canterbury, New Zealand.

McNeely, J. A. 1991, 'Biodiversity: The economics of conservation and management' in Development Research: The environmental Challenge. Winpenny, J. T. Editor. Russell Press Ltd, London.

McQueen, D. J., Churchman, G. J., Laffan, M. D. and Whitton, J. S., 1985, 'Soil properties as indicators of soil erodibility and fine sediment production in the Marlborough Sounds' in Proceedings of the Soil Dynamics and Land Use Seminar. Papers presented at a joint seminar of the New Zealand Society of Soil Science and New Zealand Soil Conservators Association, Blenheim New Zealand. I.B. Campbell (Ed).

Megahan, W. F. and Kidd, W. J., 1972, 'Effects of logging and logging roads on erosion and sediment deposition from steep terrain' in Journal of Forestry. 70:136-141.

Ministry for the Environment, 1993, People, Politics and Plans. GP Publications, Wellington.

Ministry of Agriculture and Forestry, 1976, A Strategy for the Development of the Marlborough Sounds. Ministry of Agriculture and Forestry, Wellington.

Ministry of Environment, 1997, The State of New Zealand's Environment. GP Publications, Wellington.

Ministry of Forestry, 1994, Regional Studies: Nelson and Marlborough. Ministry of Forestry, Wellington.

Ministry of Forestry, 1995, Zone Studies: Marlborough. Ministry of Forestry, Wellington.

Ministry of Forestry, 1997, New Zealand's forest growing and wood processing sector : Nelson and Marlborough. Ministry of Forestry, Wellington.

Ministry of Works and Development, 1976, A Strategy for the Conservation and Development of the Marlborough Sounds.

Morgan, D. R. and Graynoth, E. 1978. The Influence of Forestry Practices on the Ecology of Freshwater Fish in New Zealand. Fisheries Research Division Occasional Publication No.14.

Mosley, M. P., 1980, 'The impact of road erosion in the Dart Valley, Nelson' in New Zealand Journal of Forestry. 25:184-198.

Murphy, G. E., Blundell, W. M., and Fahey, B. D., 1991, Environmental Constraints on Forest Harvesting in the Marlborough Sounds. FRI Bulletin, Number 166.

Munro, R. (Ed), 1997, Fast Ferries Across Cook Strait. Complete Copy Centre, Upper Hutt.

Nature Conservation Council, 1981, Integrating Conservation and Development. Wellington.

Newton, C. G. H., 1977, The Sedimentary Dynamics of Tory Channel. Unpublished thesis for a degree of Master of Arts in Geography. University of Canterbury.

O'Loughlin, C. L., 1980, 'Resume: Near-shore sea water quality, Marlborough Sounds' in New Zealand Journal of Ecology, 3:151.

O'Loughlin, C. L., 1984, 'Effectiveness of introduced forest vegetation for protection against landslides and erosion in New Zealand's steeplands' in Symposium on Effects of Forest Land Use on Erosion and Slope Stability. 7-11 My, 1984, University of Hawaii, Honolulu, Hawaii.

O'Loughlin, C. L., 1985, 'Influences of exotic plantation forest on slope stability – implications for forest management in the Marlborough Sounds' in Proceedings of the Soil Dynamics and Land Use Seminar, May, 1985, Blenheim. Paper presented at a joint seminar of the New Zealand Society of

Soil Science and New Zelaand Soil Conservators Association. I.B. Campbell (Ed).

O'Neill, R. V., Hunsaker, C. T., Jones, K. B., Riitters, K. H., Wickham, J. D., Schwartz, P. M., Goodman, I. A., Jackson, B. L. and Baillargeon, W. S., 1997, 'Monitoring environmental quality at the landscape scale' in Bioscience, 47:513-519.

Pardy, B. 1995, "Fast Ferries: New equilibrium versus ecological sustainability" in New Zealand Law Journal. June, 1995, P. 202-204.

Parnell, K. E. 1996, Monitoring effects of ferry wash in Tory Channel and Queen Charlotte Sound. Report to the Marlborough District Council and the Regional Conservator, Nelson/Marlborough Conservancy, Department of Conservation.

Parnell, K. E., 1999, Shoreline Monitoring in Tory Channel and Queen Charlotte Sound. Progress Report prepared for the Marlborough District Council. Number 5 (April 1999).

Pasco, R. M., 1983, The Climate and Weather of Marlborough. New Zealand Meteorological Service Publication 115(12).

Paton, B.R., 1982, Sawmill Pioneers in the Pelorus. A dissertation submitted to Lincoln College in part fulfilment of the requirements of the Diploma in Parks and Recreation – Ranger Option.

Pickrill, R., 1978, 'Effects of boat wakes on the shoreline of Lake Manapouri' in New Zealand Engineering. 33:9:194-198.

Ponder, F. W., 1986, A labyrinth of Waterways. The forgotten Story of New Zealand's Marlborough Sounds. Caxton Press, Christchurch, New Zealand.

Potton, C., 1994, 'A public perception of plantation forestry' in New Zealand Forestry. 39:2:2-3.

Rails, January 2000, P.129-130.

Rails, May 1995, P. 215-217.

Rich, L. and Shaw, D. 1993, Natural and Historic Values and Areas of the Marlborough Sounds Planning District. A discussion paper on issues and options for their protection.

Riwaka, A. T., 1995, Submission for the applicants 'Save the Sounds Stop the Wash and The Atiawa Manawhenua Ki The Tau Ihu Trust. Marlborough District Council and Save the Sounds v. New Zealand Rail Limited and Sea Shuttles NZ Limited, (W14/95).

Rogers, K., 1996, Visual effects of Pine forest management. Dissertation submitted in partial fulfilment of the requirements for the Degree of Batchelor of Forestry Science. University of Canterbury.

Royal Forest and Bird Protection Society of New Zealand, 1995, Stopping The Bulldozers Before They Start: The Forest and Bird Guide to Resource Management Plans. Wellington, New Zealand.

Schofield, R. B., 1974, 'Speed of ships in restricted navigational channels' in Journal of the waterways, harbours and coastal engineering division. ASCE. P.133-149.

Schnaiberg, A., 1975, 'Social synthesis of the societal-environmental dialectic: The role of distributional impacts' in Social Science Quarterly. 56:5-20.

Simmons, I. G., 1989, Changing the Face of the Earth. Basil Blackwell, Oxford.

Simmons, I. G., 1991, Earth, Air and Water. Edward Arnold, London.

Single, M. B., 1995, Supporting evidence to the Planning Tribunal on behalf of New Zealand Rail Limited. Marlborough District Council and Save the Sounds v. New Zealand Rail Limited and Sea Shuttles NZ Limited, (W40/95).

Single, M. B., 1996 Tory Channel beach monitoring – Report of surveys February 1995 to February 1996. A Report to Tranz Rail Ltd.

Single, M.B., 1999a Tory Channel beach monitoring – Report of surveys December 1998 to January 1999. A report to the Interisland Line, Tranz Rail Ltd.

Single, M. B., 1999b Tory Channel Beach Monitoring – Report of surveys May 5th 1999 and May 15th 1999. A report to the Interisland Line, Tranz Rail Ltd.

Single, M. B. and Kirk, R. M. 1995, 'Coastal Change and Human Processes in Tory Channel, Marlborough Sounds' in Proceedings of the 18th New Zealand Geographical Society Conference. University of Canterbury. August 27-30, 1995. P. 118-121.

Soons, J. M. and Selby, M. J. 1992, Landforms of New Zealand. Longman Paul Ltd, Auckland.

Sorensen, R. M., 1967, 'Investigation of ship-generated waves' in Journal of the Waterways and Harbours Division ASCE. P.85-99.

Sorensen, R. M., 1968, 'Stereophotogrammetric analysis of wave surfaces' in Journal of the Hydraulics Division ASCE. P.181-194.

Sorensen, R. M., 1969, 'Waves generated by model ship hull' in Journal of the Waterways and Harbours Division ASCE. P.513-538.

Sorensen, R. M., 1973, 'Water waves produced by ships' in Journal of the Waterways and Harbours Division ASCE. P.245-256.

Sutherland, R. D., 20.9.2000, Environmental adviser to the marine farming and forest industry.

Sutherland, R. D., Kirk, R. M. and Bell, D. 1992, Natural Processes and Environmental Hazards in the Marlborough Sounds. A report to the Marlborough District Council in connection with preparation of the Combined Sounds/Coastal Plan.

Tait, R. V. 1981, Elements of Marine Ecology. Third edition. Butterworths. London.

The Press, 11.03.2000, P.2. 'Worry over Island erosion'.

The Press, 27.07.2000, P.7. 'Marine plan causes conflict'.

The Press, 29.07.2000, P.6. 'Top Cat wants ferry-speed exemption'.

Thomas, W. L., 1956, Man's Role in Changing the Face of the Earth. University of Chicago Press, Chicago.

Tory Channel Navigational Safety Group, 1999, Navigational Safety – Tory Channel; Discussion Document. Maritime Safety Authority of New Zealand.

Van Roon, M, no date given, Effectiveness of the New Zealand Resource Management Act (1991) and related statutes facilitation integrated coastal zone management through use of natural boundaries. Department of Planning working paper. Series Number 99-3. University of Auckland.

Van Wingarden, A, 2000, Mr van Wingarden is currently employed as the Marlborough Harbourmaster.

Vaughan, L. W., 1979, 'The possible development of a major forestry industry in Northern Marlborough' in New Zealand Journal of Ecology. 3:149-150.

Vincent, W. F., Howard-Williams, C., Downes, M. T. and Dryden, S. J., 1989, 'Underwater light and photosynthesis at three sites in Pelorus Sound, New

Zealand' in New Zealand Journal of Marine and Freshwater Research. 23:79-90.

Visser, R. and Smith, M., 1993, New Zealand Forest Code of Practise. New Zealand Logging Industry Research Organisation. Rotorua, New Zealand. Second Edition.

Weetman, G. F., 1983, 'Forestry practices and stress on Canadian forest land' in Stress on Land. Simpson-Lewis, W., McKechnie, R., Neimanis,V., (Eds). Minister of Supply and Services, Canada.

Whittow, J., 1984, The Penguin Dictionary of Physical Geography. Clays Ltd, England.

Wilks, P. J., 1980, Exotic Forestry and its Effects on Marine Farming in the Marlborough Sounds. Unpublished dissertation produced in partial fulfilment for a Master in Forestry Science, University of Canterbury.

Whittaker, T., Bell, A., Shaw, M. and Patterson, K., 2000, 'An investigation of fast ferry wash in confined waters' in 16th International Fast Ferry Conference.

World Conservation Strategy, 1980. Prepared by the International Union for Conservation of Native and Natural Resources, the United Nations Environment Programme and the World Wildlife Fund.

Zimmermann, E. W., Peach, W. N. and Constantin, J. A., 1972, Zimmermann's World Resources and Industries. Harper and Row Publishers, New York. Third Edition.